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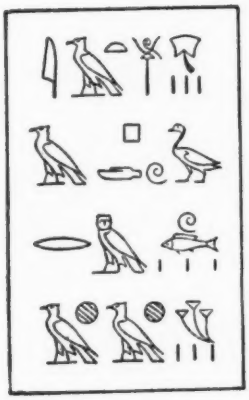

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THE JOURNAL OF WILDLIFE MANAGEMENT

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ANNUAL AND SHOOTING MORTALITY ESTIMATES FOR THE CANVASBACK

Aelred D. Geis

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The recent decline in number of canvasbacks (*Aythya valisineria*) that winter in the United States has prompted concern about the survival of the species. The major objectives of the study reported here were to determine the rate of total annual mortality, the proportion of deaths due to hunting, and the effect of hunting regulations on the size of the kill.

This paper completes a comprehensive study of the canvasback population and band-recovery data filed at the Patuxent Research Refuge. The first part was published recently (Stewart, Geis, and Evans, 1958).

Grateful acknowledgment is made to the many individuals and agencies whose bandings made the study possible; to Robert E. Stewart for assistance during the preparation of this paper; to Arthur S. Hawkins and William H. Kiel, Jr., for permission to use unpublished data; to Lucille Stickel for editorial suggestions; and to other persons in the Bureau of Sport Fisheries and Wildlife for helpful advice.

Estimates of mortality rates were based on composite dynamic life tables, the terminology being that defined by Farner (1955). Recoveries of birds banded from 1929 to 1941 were analyzed by Lack's method (Lack, 1943a, 1943b). Estimates of mean annual-mortality rates from recent banding data were calculated either by the method used by Hickey (1952:10–11, 51) or that devised by Haldane (1955). This latter technique is a modification of Lack's method and allows mortality estimates to be made from bandings that are too recent to provide data for the entire life span. It assumes that a constant rate of mortality occurs during the entire period considered.

In each of these methods, it is assumed that the number of recoveries that occur during each year is representative of the total number of deaths that occurred during the same period. In order for band recoveries that are obtained almost entirely by shooting to meet this assumption, the number of recoveries must be directly proportional to the total deaths that occur during each year.

Biased estimates will result if shooting mortality in relation to total mortality consistently increases or decreases during the entire period. It is unlikely that the results of this study were biased by any such trends, for most of the estimates are based on an average of many year classes recovered during many different hunting seasons. Bellrose and Chase (1950) point out the advisability of basing estimates on band recoveries obtained during several hunting seasons for each age class. This procedure is also recommended by Lauckhart (1956).

AGE DIFFERENCES IN MORTALITY RATES

Data for analysis came from hunting-season recoveries of canvasbacks that were banded on the breeding grounds during June through September and on wintering areas during January, February, and March. Recoveries from bandings on the breeding grounds are more useful for mortality studies, because they provide information concerning both juvenile and adult birds. Winter bandings give information on adult survival only.

Between 1953 and 1957, 950 "local" (flightless young) canvasbacks and 141 adults were banded in Manitoba and Saskatchewan. Most of the adults (91 per cent) were banded in Manitoba, whereas the locals were banded in about equal numbers in the

TABLE 1.—SUMMARY OF RECOVERIES OF CANVASBACKS BANDED IN MANITOBA AND SASKATCHEWAN, 1953–57

YEAR	FLIGHTLESS YOUNG		ADULTS	
	Number Birds Banded	Per Cent Recovered First Year	Number Birds Banded	Per Cent Recovered First Year
1953	316	21	67	13
1954	179	24	35	14
1955	127	27	18	22
1956	129	22	20	10
1957	199	19	1	—
1953–57	950	22	141	14

two provinces. Information from the provinces was combined (Table 1), because the data from the two areas were similar when viewed separately. The first-year recovery rates of locals showed some variation from year to year which may be real. When tested statistically, however, these variations did not differ significantly ($X^2 = 5.92$, 4 d.f.). It is apparent that juveniles were subjected to a relatively greater hunting kill than were adults, for the average recovery rate was 22 per cent for juveniles and only 14 per cent for adults.

A composite life table estimating the mortality rates of locals banded on the breeding grounds (Table 2) indicates that these canvasbacks had a 77 per cent mortality rate during their first year, followed by a substantially lower mortality rate during later years. The mortality rate for adults that were banded as juveniles (locals) was 52 per cent. This estimate is too high, because of the short span of years used in the calculations. The mortality estimate for juveniles probably is inflated also, but to a much lesser extent.

To obtain a more reliable estimate of adult mortality, the recoveries from birds banded as juveniles (disregarding those reported for the first hunting season after banding) were combined with recoveries of birds banded as adults. The mortality rate was estimated by Haldane's (*op. cit.*) modification of Lack's method because recoveries were available from only four hunting seasons, and according to our records canvasbacks may live as long as 9 years. The annual mortality rate for adult birds was estimated to be 41 per cent. Haldane's procedure could not be used to obtain mortality estimates for immature birds during their first year because his method yields an average mortality rate for all years combined.

Juveniles are subjected to a greater shooting kill than adults, as discussed earlier. If all other forms of canvasback mortality are not also of proportionately heavier intensity during the first year, then mortality estimates for the first year based on recoveries obtained by shooting will be exaggerated. This exaggeration probably occurs, but only to a minor extent, because, as will be discussed more fully below, shooting is responsible for more canvasback deaths than all other factors combined. Therefore, the number of recoveries obtained by shooting and the number of total deaths must be related. Also, it is possible that other forms of mor-

TABLE 2.—ABRIDGED LIFE TABLE OF CANVASBACKS BANDED AS FLIGHTLESS YOUNG IN MANITOBA AND SASKATCHEWAN DURING JUNE, JULY, AND AUGUST, 1953–57

Years after Banding[1]	Banded Birds Available	(d_x) Number Recovered	(d'_x) Mortality Series[2]	(l'_x) Survival Series	(q_x) Mortality Rate[3]
0–1	950	210	221.0	288.4	77
1–2	751	25	33.3	67.4	
2–3	622	11	17.7	34.1	52
3–4	495	5	10.1	16.4	
4–5	316	2	6.3	6.3	
Totals and mean		253	288.4	412.6	70

[1] Each year can be taken as starting on September 1.

[2] This is the d_x column converted to represent the number recovered per 1,000 banded birds available for study at each age interval.

[3] Per cent per year. Estimated by Haldane's method, the adult mortality rate is 41 per cent.

TABLE 3.—COMPARISON OF MORTALITY AND PRODUCTIVITY

Mortality		Productivity	
During first year	= 77%	Successful pairs	= 77.4%[1]
During later years	= 45%	Average ducklings fledged per brood	= 5.8%[1]
Proportion of preseason population dying each year	= 66%	Proportion of preseason population that is immature	= 69%[2]

[1] Reported for southwestern Manitoba by A. S. Hawkins and W. H. Kiel, Jr., (pers. comm.).
[2] This assumes no adult mortality between start of nesting and date of fledging.

tality affect inexperienced juveniles proportionately more severely than they affect adults. Judging from breeding-ground bandings, I conclude that an annual over-all mortality estimate of 77 per cent during the first year is a reasonable approximation, even though slightly inflated. In later years, the annual rate of this mortality is about 41 per cent.

Additional data concerning annual mortality of adults came from records of canvasbacks banded in Michigan from 1948 through 1955. Birds were banded during January, February, and March; so they included both birds wintering in Michigan and those migrating through Michigan from wintering areas on the Atlantic Coast. The mean annual rate of mortality was estimated to be 34 per cent. Banding data from other areas in more recent years indicate higher annual mortality rates. Large samples of canvasbacks were banded at the Finger Lakes, New York, and in Chesapeake Bay, Maryland, during January, February, and March of 1955, 1956, 1957, and 1958. All the Chesapeake Bay birds could be regarded as wintering birds, but both wintering birds and transients were banded in New York. Using Haldane's extension of Lack's method on these more recent bandings, I estimated the annual rate of mortality to be 50 per cent for New York and 49 per cent for Maryland bandings. Recoveries during the 1958–59 hunting season were not used in these mortality estimates because, as will be discussed below, a marked reduction occurred in the recovery rate during that season. These estimates of mortality during recent years may be biased somewhat because recoveries occurred only during a 3-year period. If one considers all areas and periods, it can be concluded that annual rates of mortality of adult canvasbacks ranged from 35 to 50 per cent and probably were about 45 per cent on the average.

As a rough check on the reasonableness of these mortality estimates, they are compared in Table 3 with data on productivity. Information on productivity was obtained from unpublished field records of A. S. Hawkins and W. H. Kiel, Jr., gathered in southwestern Manitoba from 1949 to 1953. The percentage of successful pairs shown in the table is the same as nest success, because there was very little evidence of renesting. The estimate of the proportion of the population dying each year that is shown in the table is the weighted average of the mortality rates during the first and later years. The proportion of the prehunting season population dying each year was almost identical with the proportion of the prehunting season population that was immature. This close agreement of data from the two sources indicates that the estimated mortality rates are reasonable.

SEXUAL DIFFERENCES IN MORTALITY RATES

Most samples of canvasback populations have more males than females, as is shown in numerous published reports (Beer, 1945; Ellig, 1955; Erickson, 1943; Evenden, 1952; Furniss, 1935; Hochbaum, 1944; Johnsgard and Buss, 1956; McIlhenny, 1940; Smith, 1946; Sowls, 1955). Data from the present study also showed that males were more numerous. Banding records for Michigan showed 76 per cent males; for Maryland, 66 per cent males; and for New York, 77 per cent males. Although the problem of determining true sex ratios is complicated by trapping bias (Petrides, 1946) and differential migrations and partial segregation of the sexes (Stewart, Geis, and Evans, *op. cit.*),

there is no reason to doubt that the adult sex ratio is unbalanced in favor of males. The sex ratio at hatching is about even (Hochbaum, *op. cit.*). As sex ratios of adult canvasbacks are unbalanced, females must have a higher mortality rate than males. Recovery data from different areas were analyzed to verify this. Data from birds banded in Michigan (1948–55) showed the average annual rate of mortality for males to be 33 per cent, whereas for females it was 37 per cent. Twenty per cent of 100 males and only 11 per cent of 19 females survived 5 years or more. The probability that a difference as great could arise by chance was about 0.10 ($X^2 = 2.699$, 1 d.f.), which suggests that the difference was real.

Data from birds banded at Avery Island, Louisiana, by E. A. McIlhenny (1929–41) indicated mean annual rates of mortality of 35 per cent for males and 48 per cent for females. Eight per cent of 108 males and only 2 per cent of 48 females lived 6 or more years. This difference is highly significant ($X^2 = 8.59$, $P = <0.001$, 1 d.f.). Data from birds banded in New York and Maryland (1955–57) did not show any difference in survival of the two sexes, perhaps because the bandings were so recent. Earlier bandings in New York (1923–25) indicated that 5 of 34 males (15 per cent) lived 4 or more years, whereas none of 7 females was known to survive 4 years. This difference is not statistically significant.

Recovery rates (first hunting season) for male and female canvasbacks banded in late winter and early spring were compared (Table 4) in an attempt to determine when the greatest mortality of females occurred. The table shows that recovery rates were similar for males and females, except for New York, where the recovery rate for females was significantly greater ($X^2 = 13.783$, $P = <0.001$, 1 d.f.). As we know that females do not survive as well as males in this species, these generally equal recovery rates indicate that a higher mortality of females occurs outside the hunting season. It seems most likely that this would be during the late spring and summer. It follows further that females also must have a higher rate of shooting mortality. The reason for the second conclusion is that if greater female mortality during the spring and summer were followed by an equal shooting pressure, then the females would have a lower recovery rate than males. The equal or higher recovery rate for females means that females are sufficiently more vulnerable than males to make up for their relatively smaller numbers at the time the season begins. The New York bandings indicate a higher shooting pressure against females, and from these data alone it might be concluded that the higher mortality rate for females acted mainly during the hunting season. As data from all other areas fail to show a significantly heavier hunting kill of females, it is concluded that females ordinarily have a higher rate of mortality than males during all times of the year.

TABLE 4.—AVERAGE BAND-RECOVERY RATES OF ADULTS DURING THE FIRST HUNTING SEASON (birds banded during January, February and March)

BANDING AREAS	YEARS BANDED	NUMBER BANDED		PER CENT RECOVERED	
		♂'s	♀'s	♂'s	♀'s
Louisiana	1929–41	917	468	3.1	4.5
Michigan	1948–55	1,918	606	5.0	4.6
Maryland	1955–57	1,549	818	8.1	9.2
New York	1955–57	5,403	1,631	6.5	9.2

MONTHLY DISTRIBUTION OF HUNTING KILL

There are conspicuous differences in the distribution of the hunting kill during the season for birds of different sexes and ages (Table 5). Immatures had a heavier kill than adults in September. The greatest proportion of adult females was reported during October and November, whereas the greatest proportion of adult males was reported during December and January. The kill of adult males in January was relatively much higher than that of either immatures or adult females. As adult females and all immatures showed a higher percentage of recoveries earlier in the season than did adult males, and as they are also subjected to shooting pressure late in the season, adult females and immatures of both sexes probably sustain a heavier over-all shooting pres-

TABLE 5.—MONTHLY DISTRIBUTION OF BAND RECOVERIES DURING THE HUNTING SEASON

BANDING AREAS	AGE AT TIME OF RECOVERY	NUMBER RECOVERED	RECOVERIES BY MONTH (PER CENT)				
			Sept.	Oct.	Nov.	Dec.	Jan.
Manitoba Saskatchewan	Immature	107	15	27	34	21	4
Michigan Maryland New York	Adult Female	295	2	35	24	30	9
Michigan Maryland New York	Adult Male	654	3	24	19	40	15

sure. This may be in part because adult males are not subjected to as much shooting pressure during migration as are adult females and immatures. This was pointed out by Stewart, Geis, and Evans (*op. cit.*). They found that adult males had a greater proportion of band recoveries from wintering areas than did either adult females or immatures.

PROPORTION OF DEATHS DUE TO HUNTING

Low (1957) reported that canvasbacks had a higher band-recovery rate than ducks of other species that were banded as locals in Alberta, Saskatchewan, and Manitoba during 1954 and 1955. This and other high band-recovery rates that have been reported for the canvasback suggest that shooting pressure may be responsible for a large proportion of the deaths that occur each year. Estimates of the proportions of all canvasback deaths that were due to shooting are shown in Table 6. Estimates for immature canvasbacks banded in summer were made as follows: Recovery rates for the first hunting season were adjusted to allow for failure of persons to report all banded birds they shot. In this adjustment it was assumed that 63 per cent of the banded canvasbacks that were bagged were reported. This figure was calculated from data from the Bureau's annual mail survey of waterfowl hunters by the method described by Geis and Atwood (1959). Subsequent kill-survey findings

TABLE 6.—ESTIMATES OF THE FRACTION OF CANVASBACK DEATHS DUE TO SHOOTING

Locality of Banding Years of Banding Age at Time of Recovery	Manitoba and Saskatchewan 1953–57 Immature	Louisiana 1929–41 Adult	Michigan 1948–57 Adult	New York 1955–57 Adult	Maryland 1955–57 Adult
Reported recovery rate for first hunting season	0.22	0.04	0.05	0.07	0.08
Recovery rate adjusted for nonreport of bands and for crippling loss	0.50	0.08	0.11	0.15	0.18
Total annual mortality rate	0.77	0.39	0.34	0.50	0.51
Fraction of total deaths due to hunting	0.65	0.21	0.32	0.30	0.35
Estimated first-hunting-season recovery rate for birds alive at beginning of season	0.22	0.11	0.14	0.22	0.26
Fraction of total deaths due to hunting of birds present at beginning of hunting season	0.65	0.28	0.41	0.44	0.51

indicate that 63 per cent may be too high. Recovery rates also were adjusted for crippling loss. It was assumed that for every two and one-half canvasbacks bagged, one was killed but not retrieved. Thus, the proportion of the population killed by hunters is estimated as

$$k = rac$$

where r is the reported recovery rate; a is the adjustment for nonreturn of bands ($1 \div 0.63 = 1.6$), and c is the adjustment for crippling loss ($3.5 \div 2.5 = 1.4$). The figures in the first row in Table 6 represent r; those in the second row represent rac. Row 3 of the table shows the total mortality rate (m), which was calculated as described above in this paper.

The fraction of total deaths due to hunting based on preseason bandings is $rac \div m$. Thus, for the immature canvasbacks, the fraction of total deaths due to hunting is $0.50 \div 0.77 = 0.65$.

The fifth row of the table shows the recovery rates for birds that were alive at the beginning of the hunting season. As the immature birds all were banded in the summer, they all were assumed to be alive at the beginning of the hunting season. Their recovery rate of 0.22 therefore is the same as the reported recovery rate in Row 1. This same assumption cannot be made for the adult birds that were banded in late winter and early spring, for many of them died before the hunting season. This mortality was taken into account in order to estimate the recovery rate comparable to that from preseason bandings as follows:

$$\frac{rac}{1-f(m-rac)}$$

where f is the proportion of total nonhunting deaths that occurred between the time of banding and the beginning of the hunting season, and $(m-rac)$ is the difference between the total mortality rate (m) and the total deaths due to hunting (rac). The great disparity in recovery rates between pre- and posthunting season bandings suggested that practically all nonhunting mortality occurs outside the hunting season. For purposes of calculation, it therefore was assumed that the proportion of nonhunting deaths that occurred outside the hunting season (f) was 0.9. This seemed to be a reasonable approximation of the truth.

Calculation of the adjusted recovery rate for Louisiana thus was made as follows:

$$\frac{0.08}{1-0.9\,(0.39-0.08)} = \frac{0.08}{0.72} = 0.11$$

The fraction of deaths due to hunting (Row 6) then is calculated by dividing the adjusted recovery rate (Row 5) by the total annual mortality rate (Row 3). The estimate for Louisiana thus is $0.11 \div 0.39$ or 0.28. The estimate for Michigan is 0.41; for New York, 0.44; and for Maryland, 0.51. Reliability of the estimates depends heavily on the accuracy of the estimated values used in the calculations. The values that were used are believed to be the best currently available. It is realized that they may not be entirely accurate.

Data from Louisiana, which came from birds that were banded in the 1930's and early 1940's, suggest that hunting mortality was relatively lower than in Michigan, New York, and Maryland in more recent years. More restrictive regulations and lower canvasback populations at that time may have been responsible for the difference. The discrepancy between the proportions of immature and adult deaths due to hunting probably is slightly exaggerated. Stewart, Geis, and Evans (*op. cit.*) presented evidence that birds banded in summer represented populations that were more heavily shot than did those banded in winter and spring.

Estimates of the proportion of deaths due to shooting for both immatures and adults are more likely to be too low than too high, both because the assumed proportion of banded birds taken that was reported probably was too high and because the assumed crippling loss may have been too low. It probably is safe to conclude that more than one-half of the canvasbacks that die each year die as a result of having been shot, especially since the largest segment of the population is immature and has a high shooting mortality.

EFFECT OF REGULATIONS ON THE HUNTING KILL

Several banding stations were operated with sufficient intensity over spans of years to provide first-hunting-season recovery rates during periods of different hunting regulations. In Louisiana, birds were banded from 1929 through 1941. By far the highest recovery rate occurred in 1929 (Table 7), when regulations were the most liberal. The season was 105 days long, and the daily bag limit was 25 birds. In the 4 years when the hunting seasons were reduced to 60 days, recovery rates were substantially lower. They were lower still in the 5 years having 30- to 45-day seasons. No band recoveries were reported for the 2 years in which the canvasback was given complete protection. Even excluding the years of complete protection, the differences in recovery rates still were highly significant statistically ($X^2 = 12.56$, $P = <0.01$, 2 d.f.).

TABLE 7.—EFFECT OF LENGTH OF HUNTING SEASON ON REPORTED FIRST-SEASON BAND-RECOVERY RATES IN LOUISIANA, 1929–41

Hunting Season	Season Length (Days)	Bag Limit	Number Banded	Per Cent Recovered
1929	105	25	105	9.5
1932	60	15		
1933	60	8	966	3.3
1940	60	3		
1941	60	10		
1931	30	15		
1934	30	5		
1935	30	10	300	2.0
1938	45	3		
1939	45	3		
1936	0	0	105	0
1937	0	0		

Recovery data from the banding station in Michigan were grouped into two periods of different season lengths (30–40 days as opposed to 45–70 days). The daily bag limit was four during both periods. There was a substantially lower recovery rate during the years having shorter seasons (Table 8). The difference was highly significant ($X^2 = 16.06$, $P = <0.001$, 1 d.f.).

TABLE 8.—EFFECT OF LENGTH OF HUNTING SEASON ON THE REPORTED FIRST-SEASON BAND-RECOVERY RATES IN MICHIGAN, 1948–55[1]

Hunting Season	Average Annual Duck-stamp Sales[2]	Season Length Days	Number Birds Banded	Per Cent Recovered
1948		30		
1949	415,446	40	858	2.7
1950		35		
1951		45		
1952		55		
1953	479,229	55	1,286	5.6
1954		55		
1955		70		

[1] Bag limit same in all years.

[2] Total for Maryland, Michigan, Wisconsin, Minnesota and North Dakota, where bulk of kill occurred (Stewart, Geis, and Evans, 1958).

The changes in recovery rates that were associated with changes in regulations for both the Michigan and Louisiana bandings were so great that they could not have been due to changes in the number of hunters. The highest recovery rate from Louisiana bandings was in 1929, when (although duck stamp sales figures are not available) the number of hunters probably was lower than during many of the later years. The recovery rates from Michigan bandings showed a 107 per cent increase during longer seasons, whereas the number of hunters increased only about 15 per cent in the states harvesting most of the birds (Michigan, Maryland, Wisconsin, Minnesota, and North Dakota).

Further information concerning the effects of hunting regulations was obtained from band recoveries during the 1958–59 hunting season. The daily bag limit on canvasbacks for that season was reduced to two in the Atlantic, Mississippi, and Central flyways. The bag limit had been four for several preceding years. There also was a 10-day reduction in season length in the Atlantic Flyway. After these restrictions went into effect, there was a substantial reduction in recovery rate of birds banded in Maryland, Delaware, and Saskatchewan–Manitoba (Table 9). There was no significant change in recovery rate of birds banded in New York. Although every recovery may not have been reported at the

TABLE 9.—EFFECT OF 1958 BAG LIMIT REDUCTIONS ON THE REPORTED FIRST-HUNTING-SEASON BAND-RECOVERY RATE[1]

Banding Area	Year Banded	Number Banded	First-season Recovery Rate (Per Cent)
Maryland	1955	434	9.9
	1956	835	8.6
	1957	1,098	6.7
	1958	875	2.1
New York	1955	1,369	7.5
	1956	1,948	7.7
	1957	3,698	6.0
	1958	2,348	6.0
Delaware	1956	149	9.4
	1957	359	6.4
	1958	472	2.7
Manitoba and Saskatchewan (Locals)	1953–57	950	22.1
	1958	258	13.9

[1] Reports received through January 26, 1959.

time this analysis was made (January 26, 1959), it is safe to conclude that there will not be any appreciable increase in the recovery rates, because in past years over 90 per cent of all recoveries in a given hunting season have been reported by the end of January.

The recovery rate of canvasbacks that were banded in New York did not drop. This may have been because of an unusually heavy kill during the 1958–59 season that was a result of the late hunting-season closing date in the Finger Lakes area. Only the "canvasback lakes" remained unfrozen, and hunting pressure was concentrated in these areas. This was indicated by the fact that 61 per cent of the recoveries of canvasbacks that were banded in New York were reported from New York, in contrast to only 30 per cent during previous seasons. The conclusion is supported by the fact that, although birds banded in New York are recovered throughout the same area as are birds from other banding stations, the overall recovery rate was not increased by the increase in the kill in New York. The increased kill in New York thus was compensated for by a reduced kill elsewhere. Although some of the decline in band recoveries in the 1958–59 hunting season may have been due to weather, it is very likely that the reduction in the canvasback daily bag limit contributed strongly to the markedly reduced hunting kill.

All available canvasback band-recovery data indicate that changes in regulations, either of season length or bag limit, have been reflected by changes in band-recovery rate. There is little question that hunting regulations have been effective in influencing the size of the hunting kill.

SUMMARY

Mortality rates of canvasbacks were estimated from band-recovery records. The annual rate of mortality of immatures during the first year was 77 per cent. Annual mortality rates of adults ranged from 35 to 50 per cent. Mortality rates of females were higher than those of males. Relatively larger numbers of immatures and adult females were shot early in the hunting season, and relatively larger numbers of males were shot late in the hunting season. Hunting was estimated to account each year for more than one-half the deaths of canvasbacks of flying age. Comparisons of band-recovery rates in years of different hunting regulations showed that both season length and daily bag limit affected the hunting kill.

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FOOD HABITS OF THE COUGAR IN UTAH AND NEVADA

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This paper concerns a food-habits study of the cougar or mountain lion (*Felis concolor* ssp.) made by the writers in Utah and eastern Nevada from 1946 to 1958. The study was part of a more comprehensive one aimed at an evaluation of the influence of mountain lion predation on different herds of mule deer.

The writers wish to acknowledge the assistance given by the many hunters who collected cougar stomachs and intestinal tracts, the following being especially helpful: Willis Butolph, George Nay, Walter Nelson, Adria Ahlstrom, Austin Johnson, Albert Stewart, Perry Oveson, Joseph Pearson, Vernal Montgomery, Wiley Carroll, Snap Palmer, George Proctor, Voyle Hanchett, Harold Johnson, P. O. Hurst, LaVere Kidman, Edward Connolly, Jr., Boyd Twitchell, Wallace Adams, and Russell Shores. Appreciation is also extended to Charles Sperry, formerly of the U.S. Fish and Wildlife Service, and Stephen D. Durrant, University of Utah, for assistance in identification of food items, and to the many others whose observations have been quoted in this paper.

METHODS

The writers collected cougar stomachs, intestinal tracts, and scats whenever possible and were assisted materially by many federal and private hunters who were provided jugs with Formalin in which to save specimens. Additional information on the animal's food and hunting habits was obtained from winter trailing studies.

Food found in the stomachs was identified and the wet contents weighed (after draining off surplus fluids) separately by species. Compilation of stomach contents was made on the basis of frequency of occurrence, weight, and an index described by Martin, *et al.* (1946) as the aggregate-percentage method. In the last-mentioned method, each stomach with contents was given equal weighting regardless of the amount of food. Compilation of the analysis of droppings and intestinal samples was made only on the basis of frequency of occurrence.

Only two seasons are recognized throughout our paper—"winter" (November–April) and "summer" (May–October). Further seasonal breakdown would have added little, and most of the scats could not have been dated more accurately. Many scats were classed as "summer" or "winter," depending on whether they were found on the winter or summer deer range, because seasonal distribution of deer largely dictates the distribution of cougars.

RESULTS AND DISCUSSION

A total of 277 intestinal tracts and scats and 401 stomachs were collected, but only 275 stomachs contained food (Tables 1 and 2).

Thirty were summer stomachs, and analyses revealed that this sample was likely biased because of the high proportion of domestic sheep that they contained. Most cougars in our area of study are taken with the help of hounds from November through April, when fresh snowfalls make for easier trailing; summer hunting is largely confined to individual cougars that have been preying on domestic sheep. As a consequence, it is not surprising that domestic sheep should be so prevalent in the summer stomachs. On the other hand, we believe that the summer scats and the winter stomachs, intestinal samples, and scats were randomly collected and consequently comparable, at least by the frequency of occurrence method in this study.

TABLE 1.—ANALYSES OF FOOD OF COUGARS TAKEN IN UTAH AND NEVADA, 1946–58, BASED ON 30 "SUMMER" AND 245 "WINTER" STOMACHS CONTAINING FOOD

METHOD	OCCURRENCE		WEIGHT[1]		AGGREGATE[2]	
FOOD ITEM	No.	Per Cent	Oz.	Per Cent	Total Per Cent	Weighted Per Cent
"SUMMER"[3]						
Domestic sheep	18	60	649	63.4	1,697	56.5
Mule deer	8	27	310	30.2	695	23.2
Porcupine	4	13	44	4.3	393	13.1
Bobcat	1	3	17	1.7	99	3.3
Marmot	1	3	2	0.2	5	0.2
Lagomorph	1	3	1	0.1	100	3.3
Grass	2	7	1	0.1	11	0.4
Unidentified bird	1	3	Tr.	—	Tr.	—
Totals	36	119	1,024	100.0	3,000	100.0
"WINTER"						
Mule deer	184	75	4,720	77.0	17,805	73.9
Porcupine	36	15	538	8.8	3,357	13.9
Domestic sheep	10	4	360	5.9	788	3.3
Logomorph	9	4	121	2.0	706	2.9
Beaver	3	1	208	3.4	210	0.9
Grass	13	5	5	0.1	734	3.1
Skunk	1	Tr.	54	0.9	100	0.4
Horse	1	Tr.	50	0.8	100	0.4
Cow	1	Tr.	26	0.4	100	0.4
Dog	1	Tr.	33	0.5	100	0.4
Packrat	1	Tr.	4	0.1	100	0.4
Totals	260	104	6,119	100.0	24,100	100.0

[1] Stomach food contents were totaled in ounces for each food species for all stomachs. The percentage constituted by each was thus determined.

[2] In the aggregate percentage method, the food of each stomach was accorded equal weighting—100 per cent for each stomach (Martin, *et al.* 1946). Percentage separations for individual food items in each stomach were derived from actual weight values. The percentages were totaled for all stomachs by food items and the percentage each represented to the whole determined.

[3] As the summer cougars were not taken at random—sheep killers being selectively taken for the most part (refer to text)—these results are of restricted value.

TABLE 2.—ANALYSES OF 52 "SUMMER" DROPPINGS AND 225 "WINTER" DROPPINGS AND INTESTINAL SAMPLES FROM COUGARS IN UTAH AND NEVADA

FOOD ITEMS	FREQUENCY OF OCCURRENCE			
	"Summer"		"Winter"	
	No.	Per Cent	No.	Per Cent
Mule deer	33[1]	64	167	74
Spotted fawn	(11)	(31)		
Older deer	(25)	(69)		
Porcupine	10	19	43	19
Domestic sheep	8	15	1	Tr.
Lagomorph	4	8	9	4
Grass	5	10	15	7
Beaver	4	8	2	1
Elk	1	2	2	1
Domestic goat	–	–	1	Tr.
Pocket mouse	1	2	–	–
Striped skunk	–	–	1	Tr.
Ground squirrel	1	2	–	–
Coyote	–	–	1	Tr.
Horse	–	–	1	Tr.
Totals	67	130	243	106

[1] Three scats contained hair of both spotted fawn and older deer.

To no one's surprise, the study revealed that deer (*Odocoileus hemionus*) was the all-important food species. Next in importance was the porcupine (*Erethizon dorsatum*) and domestic sheep, followed by a number of lesser important species such as beaver (*Castor canadensis*), cottontail (*Sylvilagus* spp.), hare (*Lepus* spp.), marmot (*Marmota flaviventris*), packrat (*Neotoma* spp.), skunk (*Mephitis mephitis*), horse, domestic cow, dog and goat, bobcat (*Lynx rufus*), unidentified bird, ground squirrel (*Citellus* spp.), coyote (*Canis latrans*), pocket mouse (*Perognathus* spp.), elk (*Cervus canadensis*), and grasses. A more detailed discussion by individual food species follows.

Deer

In our study, deer furnished the cougar with more food than all other prey species combined. This finding agrees with studies by Sperry (Young and Goldman, 1946), Hibben (1937), Dixon (1925), and Connolly (1949). Schwartz (1943) found varying hare (*Lepus americanus*) to be more prevalent than deer in a small collection of cougar scats from the Olympic Peninsula of Washington. This exception, however, may reflect sampling variation due to a small sample or the relative abundance of the two species rather than a preference for hares.

Deer are common throughout our region of study and the cougar's range is indelibly linked with that of the deer. Deer constituted 77 per cent by weight of the cougar's winter diet and 64 per cent of its summer diet by frequency of occurrence.

Predominance of bucks in the cougar diet.—Hunters frequently report cougars killing more bucks than does or fawns. To learn if these reports had any basis in fact, the sex and age (buck, doe, or fawn) of 186 cougar-killed deer found by the writers and co-operators were tabulated. These kills have been segregated by seasons, and their ratios compared to field-classified live deer in the same general regions (Table 3). The proportion of bucks to does taken by cougars during the winter appeared to be significantly higher than in the live herds ($\chi^2 = 13.65$; d.f. = 1; $P < 1$ per cent). The small sample of summer cougar-killed deer, however, gave a buck–doe ratio almost identical to that of live deer. If bucks are taken more readily than does during winter, as our data imply, it raises the question of why. One possible explanation is that bucks are much less wary during the rutting season of November and December—two of the winter months. Another explanation could be that following the rut, many bucks prefer ledgy, broken terrain, which is also the preferred habitat of the cougar. We believe that these reasons more logically explain the apparently higher prevalence of bucks killed rather than an actual preference for them by cougars. Stenlund (1955) reported a higher number of bucks (35) than does (28) among adult deer killed by wolves in Minnesota.

Vulnerability of fawns.—Our small sample of summer-killed deer gave a slightly lower proportion of fawns than their prevalence in the herd (Table 3). This may not reflect true conditions, however, not only because of the small sample, but also because a greater proportion of a newly born fawn can be devoured than an older deer,

TABLE 3.—COMPARISON OF NUMBERS AND RATIOS OF COUGAR-KILLED DEER AND FIELD-CLASSIFIED LIVE DEER DURING "SUMMER" AND "WINTER" IN UTAH AND EASTERN NEVADA

SEASON	COUGAR-KILLED DEER				CLASSIFIED LIVE DEER			
	Bucks	Does	Fawns	Totals	Bucks	Does	Fawns	Totals
"Summer" number	9	18	9	36	3,619	7,147	5,525	16,291
"Summer" ratio	50	100	50		51	100	77	
"Winter" number	42	58	50	150	4,650	13,679	10,834	29,163
"Winter" ratio	72	100	82		36	100	79	

leaving less evidence of the kill. Summer scats revealed the remains of 11 spotted fawns for 25 older deer or 31 per cent of the total compared to 25 per cent from remains of summer cougar-killed deer and 24 per cent for the live herd. It must be remembered, however, that the majority of fawns are not spotted for more than a 2.5-month period. This period represents only 40 per cent of the 6-month summer period, so it appears entirely possible that young spotted fawns could have been taken one and one-half to two times more frequently than their relative prevalence in the herd. Not only should young fawns be more easily taken than older deer, but they may even be preferred by the cougar. Pertinent to the present discussion are the following accounts of cougars capturing young fawns.

Myron Hanchett of Annabella, Utah, related to the senior writer the following observation which he made in August 1934, while herding sheep on Monroe Mountain in central Utah. Mr. Hanchett heard the distressed bleating of a fawn and subsequently saw a half-grown cougar in close pursuit. The fawn was so exhausted that it fell down only a few feet from the observer. The lion, upon seeing the human intruder, whirled and left the scene. A search in the area revealed another half-grown lion and the partially devoured remains of a young fawn.

Archie Murchie, of the U.S. Forest Service, furnished the writers with another observation which his road patrolman, Walter Ray, made in the summer of 1939. At the time, Ray was about 18 miles below the Loon Creek Ranger Station within the Challis National Forest in Idaho when he noted a doe running, as though troubled, from the heavy brush bordering the creek. Ray crawled into the brush and frightened a cougar which he found playing with a young fawn. The fawn was still alive but badly mauled and was wet from the cougar's saliva. It was able to walk away but the full extent of its injuries was not ascertained. Had it not been for human intervention, it seems certain that the fawn would ultimately have been killed and eaten.

In yet another instance, hunter Phil Hurst related to us how workers on a new gas line near Fairview, Utah, came upon a cougar carrying a young fawn in its mouth, early on the morning of July 1, 1954. The cougar dropped the fawn and fled upon seeing the workers. Hurst was contacted a few hours later and while he found the fawn and cougar tracks, his dogs were unable to follow the scent.

The ratio of does to fawns killed by cougars during the winter was almost the same as that observed among live deer in the herds. Similarly, Stenlund (*op. cit.*) found wolves displaying no preference for fawns during the winter in Minnesota.

Method of attack.—General observations and accounts in the literature indicate that cougars, in stalking deer, attempt to sneak within leaping distance, although they are capable of running deer down in distances up to 50 yards. The cougar usually jumps onto the deer's back, holding on with its claws as it bites into the nape of the deer's neck. If the deer is not killed by this bite or the subsequent fall to the ground, it is finished off by a series of bites in the jugular region.

Following the kill, the cougar usually drags its quarry to some secluded spot under a tree or ledge before feeding. Fifteen recorded distances over which cougars were noted to drag deer in this study averaged 305 ft. with a range from 16 to 1,100 ft. The first feeding is commonly from the liver, heart, and lungs through an opening sheared in the ribs. When full, the cougar usually covers the carcass with dirt, sticks, snow, leaves, or anything available within 3 or 4 ft., although it will probably not cover the carcass if nothing remains to be eaten.

Some disagreement exists in the literature as to the manner in which cougars kill deer. Bruce (1922), who in his professional career

took more than 600 cougars in California, states that after a deer is knocked down it is killed by disembowelment. Examinations by Bruce of about 100 cougar-killed deer revealed no evidence that their throats had been touched. Musgrave (1926) states that a cougar pounces on the back of its prey, fastening its front claws in the shoulders and hind claws in the flanks and killing with a bite through the back of the neck. Wade (1929), in an eyewitness account, states that the cougar spread out and landed full length on the deer's back, its left paw catching the chest region, the right hitting the deer's neck, knocking it around to one side. The deer went down immediately, and there was no struggle. The cougar proceeded to pull and half carry the deer by the neck for 10 to 15 ft. before starting to feed. Allen (1949) observed a cougar kill a deer under captive conditions and reported that the cougar sprang onto the deer from a distance of 15 ft., grabbing the deer's neck in its mouth and its shoulder with a front paw. After the deer went down in a heap, the cougar continued chewing its neck until struggling ceased. Hibben (*op. cit.*) reports that the leap of a cougar onto a deer may in itself be sufficient to cause death by breaking the victim's neck; however, in all but 2 of some 50-odd kills examined, tooth marks found on the back and neck were believed sufficient to have caused death. Denton and Kent (1956) report that cougars bite deer on the back of the neck. All cougar-killed deer that they examined had broken necks. We have examined closely only eight deer freshly killed by cougars. Two of the deer had broken necks. In the remaining six, however, it was evident that death had resulted from a series of bites on the throat, as deduced from the large number of tooth marks and clotted blood found in the jugular region. With a single exception, each deer had a single set of tooth marks on the nape of the neck, as was plainly evident upon skinning out the neck of each animal.

A bite on the nape of a deer's neck probably has the same paralyzing effect which "creasing" has upon horses. Creasing has occasionally been employed by western range men as a means of capturing wild horses. It consists of a carefully placed rifle shot that barely nicks the dorsal part of the horse's neck. The animal is temporarily stunned, perhaps from shock to the spinal cord, thereby permitting its easy capture. It subsequently recovers, if not seriously wounded. The senior author once shot a deer accidentally in this manner, the bullet barely grazing the back of the animal's neck. The deer dropped immediately and, although it regained its feet shortly after, remained in a standing stupor until dispatched with another shot. A cougar's bite could produce the same effect. If the deer's neck is not broken by this initial bite or the subsequent fall to the ground, our observations would indicate that it is ultimately killed by repeated bites in the throat region. A number of observations are described in the following passages to illustrate some of the hunting and feeding habits of cougars as related to deer.

An eyewitness account that bears recording has been related to us by William Alldredge, Oak City, Utah, of a cougar stalking and killing a deer. At the time, Alldredge was hired by the senior author to assist in a fawn-tagging program. He had spent the late daylight hours of June 7, 1957, on a high ledge scanning the nearby slopes for does with young fawns. About 7:30 P.M., he espied a large cougar about 100 yd. distant on the talus slope below, working its way toward a group of six feeding deer. It took the cougar only a few minutes to make its way through the scrub oak (*Quercus gambelii*) and waist-high sagebrush (*Artemisia tridentata*) to within 10 ft. of the closest deer—which later proved to be a yearling doe. The cougar crouched and waited behind a sage bush until the deer came within 5 ft., when it leaped and caught her rear parts with its front paws, having been thwarted in making a clean leap by the intervening brush. The deer was forced to its haunches but started pawing its way down the steep slope with its free front feet, bleating as it went. After struggling for 70 ft., deer and cougar stumbled, rolled over, and disappeared from view through a small

clump of scrub oak. The remaining five deer, which had been feeding only 40–60 ft. away, watched intently and did not flee until cougar and deer had disappeared. Observations by Alldredge and the senior author on the following day revealed that the deer had been killed at the lower edge of the clump of oak. Blood and deer hair were abundantly evident in an area 4–5 ft. across. A large boulder weighing an estimated 200–300 lb. had been overturned in the struggle. From the place of kill to the base of the talus slope, a distance of about 50 yd., it was apparent that the cougar had carried its quarry, for there was no drag trail in the lush growth of forbs. At one point, where the cougar had passed between two scrub oaks, deer hair had rubbed off on a branch 18 in. above the ground. At the bottom of the slope, a drag trail was clearly visible. It led for 80 yd. to the edge of a 5-ft.-wide stream, which the cougar had decided not to cross for it retraced its trail to where it had descended from the talus slope. Here the deer was found covered with leaves and weeds beneath a maple tree (*Acer grandidentatum*). A circular opening had been chewed in the deer's side next to the ribs, through which the liver had been eaten and the uneaten stomach and intestines removed. A number of tooth marks and a considerable amount of clotted blood were found in the throat region, but none on the nape.

Cougars are not always fortunate enough to catch their prey in a single leap, as in the foregoing account. Signs observed in the snow by the senior author in the Eight-mile Area of central Utah on January 22, 1951, revealed that a mature male cougar (later caught) was forced to make 19 leaps covering 144 ft. before catching a mature doe. A trodden-down area of perhaps 100 sq. ft. marked the site where the doe was brought down. She had been dragged 108 ft. to an overhanging ledge and partially covered with snow, sticks, and leaves. The doe had been disemboweled and the heart, liver, lungs, much of the loin, and the ribs on one side consumed. Disembowelment is a fairly common procedure for cougars and, while Bruce (*op. cit.*) believed this to be the means by which cougars kill deer, we believe it is merely a sanitary measure by which the cougar removes what it regards as distasteful from the desirable portions. The action probably serves the added function of preserving the meat from early spoilage, especially in warm weather. It is only when driven by hunger that we have observed instances where cougars have eaten the intestines or stomachs of prey species. We have noted a number of deer carcasses where all edible parts have been taken except the stomach and intestines. Wright (*op. cit.*), upon frightening a cougar away from two freshly killed and covered fawns, found both had been disemboweled. The entrails were still attached to the carcasses, but were outside the body cavities. The only flesh eaten was part of the rear flank of one fawn. When Wright returned 3 days later, nearly all fleshy parts had been eaten, with only the heads, lower legs, and viscera remaining.

In an observation on November 29, 1951, the senior author found where a cougar had killed a yearling buck in the Oak Creek area of central Utah. The cougar had paralleled a group of deer for about 40 ft., sneaking behind some clumps of manzanita (*Arctostaphylos patula*) until within 8 ft. of its prey before leaping. The deer made two leaps of about 6 ft. each before momentarily going down. It regained its feet, making another leap of approximately the same distance before finally going down. A struggle ensued for about 12 ft. where blood in the snow marked the end for the deer. The drag trail was then followed downslope for about 1,100 ft. to where the deer was found covered with debris under a pinyon tree (*Pinus monophylla*) at the base of a large ledge. The cougar had fed on the front shoulder, eaten through the ribs on one side and taken the heart, lungs, and part of the liver. It had been resting on the adjacent ledge but fled on the approach of the senior author, as evidenced by the fresh tracks and long leaps registered in the melting snow. Tooth marks were found both on the back of the victim's neck and on the throat, the latter having been thoroughly macerated.

On January 22, 1947, Forrest Romero, a former assistant of the senior author, observed in the snow where a cougar had killed a large mature buck 3 days previously in Salina Canyon of central Utah. The cougar had paralleled the deer for a short distance before charging in leaps of 5, 5, 6, 7, 9, and 10 ft. The deer did not regain his feet after being hit, but a struggle ensued on the ground. Subsequently, the buck was dragged 54 ft. to the cover of a juniper (*Juniperus utahensis*), where some of a hind quarter, the liver, and chest organs had been consumed. Another mature, cougar-killed buck was found in the same general area. It had been dragged 162 ft. to some cover, where the cougar had fed on the chest organs.

Archie Murchie surprised a cougar that was covering the still-warm carcass of a mature mule deer doe in the Duck Creek area of Nevada at about 8 A.M. on September 26, 1950. From signs in the dirt, it was apparent that the cougar had crept behind a currant bush (*Ribes* sp.) to within 12 ft. of the deer before springing. The deer was apparently killed on the spot and dragged about 20 ft. across a small wash. An estimated 5 lb. of flesh had been taken from the flank and hind quarter. When he next visited the area 3 weeks later, Murchie found the carcass completely eaten save for the larger bones.

Murchie made another interesting observation in the same area on October 1, 1954. He found the covered remains of a mature doe killed the previous night. The cougar had dragged the deer 20–25 ft. into a clump of spruce trees, where it had fed. The only visible tooth marks on the deer's neck were on the nape. Subsequent observations proved that the cougar returned to feed on each of the following 4 nights, covering the carcass each time except the last one, at which time all edible parts had been consumed. Only the stomach, intestines, larger bones, and portions of the hide remained uneaten. The cougar returned the second night and fed even though Murchie and family were camped only 100 yd. away.

On still another occasion Murchie found a cougar-killed mule deer doe inside a 40-by-40-ft. livestock exclosure on April 9, 1951. A fence, consisting of 4 ft. of woven wire topped by two strands of barbed wire, had been built around Blue Spring on Ward Mountain in eastern Nevada to exclude livestock. Inasmuch as water from the spring was not flowing outside the exclosure, the deer had evidently jumped in for a drink, only to be killed by the cougar. The liver, chest organs, and lesser amounts from a hind quarter and a front shoulder had been fed on, with no attempt having been made to cover the carcass. Observations the following day showed that the cougar had returned the preceding night for another meal and on this occasion had dragged the doe to two different corners of the exclosure in a vain attempt to remove her from the fenced area.

On October 10, 1951, two deer hunters related to the senior author how they had surprised a cougar feeding on a deer in the Duck Creek area of Nevada. The hunters reportedly shot at and "bowled" the cougar over, but were reluctant to follow in the heavy cover where it had escaped. Only the chest organs of the deer had been eaten. Five days later, when the senior author visited the site, he found the 3- to 4-month-old fawn completely devoured save for the leg bones (still attached by thin strands of hide), part of the head, the stomach, and some of the intestines. Both ears had been sheared from the head as though cut with scissors, but strangely enough left uneaten. (This peculiarity has been noted on two other occasions by the writers.) Even the brains of this fawn had been eaten—something which seldom happens with mature deer because of the heavier skull bones. Presumably, a single cougar was involved in the foregoing observation, and if so, it is surprising that it would return to feed after having been shot at.

On January 6, 1950, Austin Johnson of Delta, Utah, observed where a cougar had killed a mature doe about 2 days previously on the Canyon Range in central Utah. The doe had managed to run for nearly 100 yd. after the cougar had jumped onto her. The only sign of the cougar showing in the snow during that distance was the drag mark of a hind foot, which probably had temporarily lost its grip on the deer. After the kill, the cougar alternately dragged and carried its victim for about a quarter of a mile uphill before feeding. It was evident that the doe had been carried part of the way across the back of the cougar, for the only drag marks left by the deer during those stretches were from its hind feet.

On February 17, 1950, the senior author found a female fawn in the Duck Creek area of Nevada that had been killed by a female cougar about 6 days previously. It had been dragged about 980 ft., as determined through pacing, before the cougar and her two 25-lb. cubs had fed on the chest organs. The carcass was found sparsely covered with dried grass and sticks under a curlleaf mountainmahogany tree (*Cercocarpus ledifolius*). The lioness and cubs returned to the kill on the night of the 17th. This time they dragged the carcass an additional 65 ft., where it was found uncovered under another mountainmahogany. Most of the flesh from the back and legs had been consumed. Despite a close chase by hounds and the capture of one cub on the 18th, the lioness and remaining cub returned to the fawn carcass again on the night of the 19th. This time the fawn remains were moved another 10 ft. to another mountainmahogany. All remaining flesh except the stomach and large intestine had been eaten, as had the ribs, many vertebrae, most of the hide, and even the brains. Thus, these cougars in three feedings during an 8-day period consumed an estimated 45 lb. from the fawn. What else they may have fed on during the period was not known, because southern exposures, barren of snow, prevented continuous trailing. However, the exceptionally strong odor of skunk on the morning of the 18th in the vicinity of the fawn carcass suggested that other prey may have been taken.

Food requirements.—Much speculation has arisen in the literature as to the number of deer taken by a cougar during a year's time. Most estimates range from 35 to 100 (Cahalane, 1954; Connolly, *op. cit.*; Grinnell, *et al.*, 1937; and others), although much higher rates have been reported for shorter periods. We have obtained little quantitative data through trailing observations. However, it seems worth while to make a rough computation of the winter rate from such data as: daily food requirements of the cougar, average amount of flesh consumed from each deer killed by cougars, and proportion of a cougar's diet made up of deer.

The daily food requirements of a cougar in the wild is conjectural. However, mature cougars in the Washington, D.C., and Salt Lake City, Utah, zoos are fed from 5 to 7 lb. of meat daily. Wild cougars perhaps require more because of their greater activity. Earlier in this paper an account was given of a mature cougar cleaning up the edible parts (except the stomach, intestines, larger bones, and a portion of the hide) of a mature doe in 5 consecutive nights of feeding. Hog-dressed weights of mature does from the same area averaged 88 lb. during the 1951 hunting season. Hamerstrom and Camburn (1950) report the fully dressed weights of mature white-tailed does as averaging 67 per cent of the hog-dressed weight. Thus, we could expect a fully dressed weight of about 59 lb. for a mature Duck Creek doe. While it is true that a cougar consumes the heart, liver, lungs, and parts of the hide, which are excluded from the fully dressed weight, we suspect that these parts may about balance the weight of the vertebral column and leg bones included in the fully dressed weight, but which usually are not eaten. With this assumption, it appears that the cougar in question consumed an estimated 59 lb. of venison in 5 nights for a daily average of nearly 12 lb. This is double the ration mentioned for zoo animals. The heaviest stomach contents for a mature cougar encountered in our study were 9 lb. 9 oz. of domestic sheep, but some digestion had possibly transpired at the time of death. On the other hand, it is possible that the cougar that apparently ate 12 lb. nightly fed more than once each night.

Cougars do not always completely clean up deer that they kill. In some instances they may feed but once, while on other occasions they devour everything edible. We have made estimates of the proportions of edible parts consumed by cougars from 19 cougar-killed deer that were no longer being fed on by cougars, and that we believe had not been fed on by bobcats or coyotes. The observations were made during winter when a snow cover aided interpretations. Carcasses being currently used when found were not counted if the cougar discontinued feeding, apparently because of human intrusion. We cannot say categorically that cougars would not have returned to any of the carcasses, the flesh of which had not been completely eaten, but absence of fresh cougar signs and state of the deer carcasses were used as criteria in our judgment. An average of the 19 estimates was 63 per cent, meaning that this proportion of the edible parts had been taken—excluding the stomach, intestines, larger bones, and most of the hide.

Hog-dressed weights of hunter-killed deer from central Utah have averaged 124, 94, and 51 lb., respectively, for bucks, does, and fawns. The computed fully dressed weights are 89, 63, and 36 lb., respectively, based on percentages by Hamerstrom and Camburn (*ibid.*). Weighted according to the proportion of bucks, does, and fawns killed during winter by cougars (Table 1), the computed fully dressed weight of the average cougar-killed deer would be 61 lb. Of this weight, we estimate the cougar would take 63 per cent, or 38 lb. Table 2 shows that about 77 per cent (by weight) of the cougar's winter diet is composed of deer, so for every 38 lb. of deer eaten, an additional 11 lb. of other food is also taken. A zoo animal eating 5 lb. daily would require 10 days to consume 49 lb., whereas only 4 days would be necessary at the 12-lb. rate. The actual rate for a wild cougar population would likely be somewhere between these extremes. The wild population includes many immature animals with appetites that

are somewhat less than those of the mature ones on which the above rates were based. Also, in the case of the cougar that consumed an estimated 12 lb. daily for 5 consecutive days, it is probable that the rate would be somewhat lower if determinable for a longer period. Offsetting these two factors somewhat could be the greater appetite that wild animals probably have over captive ones.

Connolly (*op. cit.*) determined from winter tracking studies in Utah and Nevada that a cougar killed one deer on the average of every 10 days. From our own computations, a reasonable estimate would seem to be a deer weekly during the winter period. Table 2 indicates that deer are less prevalent in the cougar's summer diet, a condition corroborated by Sperry's findings (Young and Goldman, *op. cit.*). This does not necessarily mean that deer are killed less frequently. Jack Butler, who is Utah's top cougar hunter, having taken around one thousand during his career, states categorically that cougars kill more deer during summer than winter in our area of study. His statement has some basis of fact because cougars, like most cats, do not care for tainted food and during the hot summer months spoilage may set in within a day or two following kill. The well-developed habit cougars have of covering uneaten prey may have some preservation values. It would not only serve to keep flies from reaching the meat, and magpies (*Pica pica*), ravens (*Corvus corax*), etc. from discovering the kill so readily, but a covering of leaves, sticks, and other debris would provide some insulation, which might delay spoilage. Often cougars will remove the viscera from a deer carcass, an action that likewise would delay spoilage.

The reduced prevalence of deer in the cougar's summer diet is compensated by an increased consumption of domestic sheep, lagomorphs, and rodents.

Porcupine

Occupying a strong second position in the cougar's diet is the porcupine. It made up 8.8 per cent by weight of the cougar's winter diet and 19 per cent by frequency of occurrence from scat and intestinal samples for both winter and summer.

Connolly (*op. cit.*) found from his winter tracking studies that a cougar killed one porcupine a week on the average. It is generally believed that the cougar kills a porcupine by flipping it over with a paw and attacking the unprotected belly. An eyewitness account related to us by Virgil Draney, presently Supervisor of Fur Resources for the Utah Fish and Game Department, tends to corroborate this belief. Near evening in October 1937, Draney saw a cougar approach a porcupine that was feeding in a small meadow by Worm Creek, which lies east of Preston, Idaho. The cougar watched the porcupine at close range for several minutes before seeing an opportunity to slip its paw beneath the porcupine. As it did so, it flipped the hapless animal into the air, disemboweling it in the process. The cougar licked its paw and then commenced devouring its prey on the spot.

Clifton Stewart and John Mitchell, seasonally employed by the U.S. Forest Service, were driving up a mountain road in central Utah shortly after a storm in late June 1955, when they noticed fresh cougar tracks in the road ahead. Shortly thereafter, they came upon a freshly killed young porcupine, its belly ripped open and entrails protruding. Apparently, the cougar had been frightened from the kill by the approaching car, for the porcupine was still warm.

The senior author once frightened three yearling cougars from a freshly killed porcupine in Dry Creek near Monroe, Utah, on February 1, 1943. Blood was still oozing from the only visible wound, a large opening on the throat. It was not determined, however, whether the wound had been made by the claws or teeth of the cougars.

The writers have found remains of cougar-killed porcupines on numerous occasions, and the hide always gives the appearance of having been skinned out. The feet may or may not be eaten, but the head, stomach, and intestines are rarely taken. Some quills are consumed by the cougar, as they have been found in the stomach and even stuck in the stomach walls, but apparently with no se-

rious consequences. The following account, however, indicates that preying on porcupines, especially by young inexperienced cougars, is not without its hazards. Hunters Lloyd Roberts and Voyle Hanchett killed a mature female cougar in Monroe Canyon of central Utah in December 1927. It was not until 12 days later, however, that they were able to return to capture her four, 1/3-grown cubs alive. The cubs had subsisted largely on porcupines during the interim, as evidenced by the large number of quills in the three largest ones, but they lived only a week following capture. The fourth cub was a runt and, ironically, the only one to survive. Being a runt and less aggressive than its litter mates, it apparently had been content to let them do the killing, thereby being spared the quills. Cougar young are probably taught the art of porcupine killing by their mothers, but in this instance it was evident that the cub had not yet acquired the art.

Domestic Sheep

The percentage of occurrence for sheep in the summer scats is a high 15 per cent but less than 1 per cent during winter. Analyses of winter stomachs, however, gave an occurrence of 4 per cent. The variation in winter samples is probably due to sampling. It does appear, however, that the kill of sheep is appreciably higher during summer than in winter. This is likely a reflection of availability rather than preference. As mentioned earlier, large herds of sheep graze during summer in the mountains, which are cougar habitat. During winter, however, most of the herds graze in the desert valleys, where cougars seldom range.

The occurrence of sheep in the cougar stomachs and scats is not a true reflection of the damage inflicted on sheep herds by cougars. Frequently a cougar will invade a herd and kill many more sheep than he can ever hope to eat, merely because the killing is so easy. One case in Nevada came to our attention of a cougar killing 17 sheep in 1 night. The cougar rarely can feed more than 1 or 2 nights before the herder or hunters are after him, and so has little opportunity to clean up the kills. We analyzed one cougar stomach that contained both portions of a ewe and of her unborn lamb.

Lagomorphs and Beaver

Cottontail and black-tailed jack rabbit (*Lepus californicus*) were both identified in the cougar stomachs and scats, but no distinction was made in a few instances, so lagomorphs have been treated collectively. White-tailed jack rabbits (*L. townsendii*) and varying hares, while not specifically identified in the cougar food remains, are probably taken on occasions, for both species are found within the range of the cougar in Utah and Nevada. Lagomorphs probably rank about fourth among cougar foods after deer, porcupine, and domestic sheep. Beaver outranked lagomorphs during winter on the basis of weight of stomach contents, but frequency of occurrence indicated that lagomorphs were taken with much greater frequency both in winter and summer.

On the basis of winter stomach analyses, beaver made up 3.4 per cent by weight of their contents, which exceeded the 2.1 per cent recorded for lagomorphs. One stomach, containing 7 lb. 10 oz. of beaver, perhaps inflated the weight percentage excessively. Beaver, when searching for food away from water, should be easy prey for the cougar.

Grass

Grass occurs rather frequently in the cougar's diet both in winter and summer. Frequency of occurrence was as high as 10 per cent but, on the basis of weight, it was a minor item. The writers have never received a definitive answer to the question of why cats eat grass. Green grass might furnish vitamin A or other nutrients, but brown, coarse, giant ryegrass (*Elymus candensatus*) and other coarse grasses are taken during winter with equal frequency when the nutrient content is negligible. Even livestock shun giant ryegrass during the winter. Speelman (1939) states that the primary function of vegetables in a dog's ration is to furnish vitamins and minerals, supply bulk, and by acting as fillers serve to regulate the bowels. Grass may serve similarly in the cougar.

Minor Food Items

Other items of food that appeared in the stomachs, intestines, and scats of cougars during this study were: striped skunk, packrat, horse, cow, dog, pocket mouse, marmot, unidentified bird, domestic goat, elk, ground squirrel, coyote, and bobcat.

The single stomach containing horse was from a large male cougar killed by federal hunter Willis Butolph while he was hunting in the Flat Canyon area of central Utah, January 29, 1956. Butolph had been trailing the cougar, which in turn had been following the tracks of two cows, when the tracks of a wild horse were noted. Shortly after, blood and evidence of a struggle were observed in the snow. About 75 yd. from the first blood was the carcass of the horse. It was apparent from signs in the snow that the horse had gone down when first hit, but had regained its feet and traveled the 75 yd. before succumbing. Drag marks of the cougar's hind feet were noted for a short distance after the horse fell and regained its feet. While the cougar had apparently lost its grip on the horse momentarily with its hind feet, it had evidently held on securely with its front feet and teeth. The horse was a mature mustang, judged by Butolph to weigh around 900 lb. The cougar had fed only from the region of the diaphragm. It was jumped by the hounds nearby, and after a short chase was treed and shot.

The single stomach containing bobcat was from a mature male cougar killed by Butolph, July 27, 1950, in Cedar Canyon of southern Utah. The same stomach also contained a trace of unidentified bird. While we have listed this among the food of the cougar, it is entirely possible that this particular bird was eaten initially by the bobcat.

Two of the writers (Robinette and Gashwiler) were in the Duck Creek area of eastern Nevada on February 12, 1950, when the late Anton Sutich, biologist with the Nevada State Fish and Game Commission, found a mature male bobcat recently killed and partially eaten by a cougar. The senior author was able to check the scene the following day. The bobcat had been covered except for its feet, which protruded from the freshly packed mound of snow. Its midsection had been devoured—the front and rear sections being held together only by some of the hide. Although numerous cougar, bobcat, magpie, and rabbit tracks in the vicinity somewhat obscured reconstruction of the action, it appeared that the cougar had surprised the bobcat at a deer carcass, which was discovered about 70 ft. away. The bobcat's stomach, which was located in the snow mound, contained 3.5 oz. of deer. The head and neck of the bobcat, when skinned out, revealed that death had resulted from a single bite in the neck. The bobcat weighed 17 lb. despite the loss of several pounds eaten by the cougar. Bruce (*op. cit.*) and Young and Goldman (*op. cit.*) have mentioned that cougars occasionally take bobcats. On February 4, 1951, Butolph found where three lions had killed and completely devoured a bobcat save for head and feet in the Pine Grove area of southern Utah. Trappers, on several occasions, have informed us of cougars feeding on bobcats and coyotes that had been caught in their traps.

Domestic cow was found in but one stomach—this being from a mature male cougar killed by federal hunter George Nay in Willow Creek of northeastern Utah, on January 14, 1952. While he was hunting, Nay chanced onto the carcass of the recently killed, immature Hereford. He caught the cougar shortly after. In our area of study, cattle are generally unavailable to cougars during winter. However, the fact that cow did not appear in any of the summer scats, at a time when cattle are available, leads us to believe that they are not often molested, if deer are plentiful.

MISCELLANEOUS OBSERVATIONS

Cougars live almost exclusively on prey that they have killed. Occasional exceptions have been noted, however. Federal hunters in Utah and Nevada have found several cougars that apparently died from feeding on "1080" poison stations placed out for coyote control. We likewise have encountered three authentic cases of cougars having fed on field-dressed deer left in the

mountains by hunters to cool out overnight. In still another instance, the stomach from a cougar killed during winter in Utah contained 7 lb. 10 oz. of beaver. The contents were unusual in that no hide was present—only an occasional hair permitted identification. Absence of hide suggested that the cougar had fed on a skinned carcass.

An unusual stomach was taken from a mature female cougar killed by Willis Butolph and Adria Ahlstrom in the Corn Creek area of central Utah, on January 4, 1951. The stomach had a conspicuous constriction about its midsection. Removal of a heavy covering of connective tissue revealed an opening through the wall of the stomach in the region of the lesser curvature. The opening presented the appearance of a person's pursed lips. In the forepart of the stomach were 2 oz. of deer liver, while a similar amount of deer hair and bones was found near the pylorus. Cause for the wound is a matter for speculation. It could have resulted from a rifle shot or possibly a splintered deer bone, but whatever the cause, it was surprising that the cougar had been able to survive.

SUMMARY

In this study, 277 intestinal tracts and scats and 401 stomachs from cougars were collected in 1946–58 in Utah and Nevada. Only 275 of the stomachs, however, contained food. Only two seasons—"winter" and "summer"—were recognized in the analyses. Mule deer was by far the most important food, making up nearly 80 per cent of that taken during winter and nearly two-thirds during summer. Porcupine comprised about 10 per cent, with other foods, such as domestic livestock, lagomorphs, beaver, squirrels, mice, elk, coyote, bobcat, skunk, and grass, making up most of the remainder.

Buck deer appeared to be killed by cougar more frequently than their proportionate numbers in the herds during winter. The same condition is possibly true for young fawns during the first 2 or 3 months following birth, but the evidence is not conclusive.

Some rough computations based on the daily food requirements of cougars, the amount of meat consumed from the average deer, and the proportion of the diet consisting of deer indicated that a cougar kills a deer every 4 to 10 days for an average of one weekly during the cool winter months (November–April). There is some reason to believe the kill rate might be greater during summer.

A number of observations on the hunting habits of cougars are recounted.

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A VEGETATIONAL STUDY OF THE CENTRAL WISCONSIN WINTER DEER RANGE[1]

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The white-tailed deer (*Odocoileus virginianus*) inhabiting central Wisconsin utilize the low-growing, ground-layer plants as winter browse. Such plants are available to the deer in this region (Fig. 1) primarily because the snow accumulation is not ordinarily great. The important ground-layer plants that provide a rather high percentage of the winter food supply in central Wisconsin are wintergreen (*Gaultheria procumbens*), dewberry (*Rubus pubescens*), partridge berry (*Mitchella repens*), bearberry (*Arctostaphylos uva-ursi*), pipsissewa (*Chimaphila umbellata*) and trailing arbutus (*Epigaea repens*). Of lesser importance are shinleaf (*Pyrola* sp.) and blueberry (*Vaccinium angustifolium*).

Preliminary observations of the winter deer range in central Wisconsin led to the hypothesis that these important browse species were decreasing in numbers. These observations by personnel of the Wisconsin Conservation Department prompted the initiation of the study reported here, which was carried out during the summer of 1958. The project was designed to obtain accurate information on the phytosociological behavior of the ground-layer plants in the forest-community succession in central Wisconsin, and, also, to determine whether or not the present level of winter deer activity imposed on these plants is exerting a detrimental effect on their numbers.

Characteristics of the Region

Two principal areas in central Wisconsin (Fig. 1) were included in this study: (1) the Central Wisconsin Conservation Area (C.W.C.A.), located in northwestern Juneau County and portions of Monroe County; and (2) the Black River State Forest, situated in Jackson County. Together, these two state-owned tracts comprise approximately 116,000 acres.

The Black River State Forest and the C.W.C.A. are both located within the Wisconsin Driftless Area, and the C.W.C.A. itself lies entirely within the bed of Glacial Lake Wisconsin (Martin, 1932). Much of the central Wisconsin area may be described as a nearly level sand plain with occasional sandstone and quartzite hills and cliffs projecting above this plain (Whitson, *et al.*, 1914, 1923). There are also extensive areas of marshland in the region, many of which are used for cranberry cultivation.

Early descriptions of the vegetation in central Wisconsin (Ellis, 1857; Roth, 1898; Bordner, *et al.*, 1934) reveal that much of the area was a mosaic of tall-grass prairie, pine and oak openings, and islands of mature red pine (*Pinus resinosa*) and white pine (*P. strobus*). Essentially, this was a mixture of vegetational elements representative of both southern and northern Wisconsin plant

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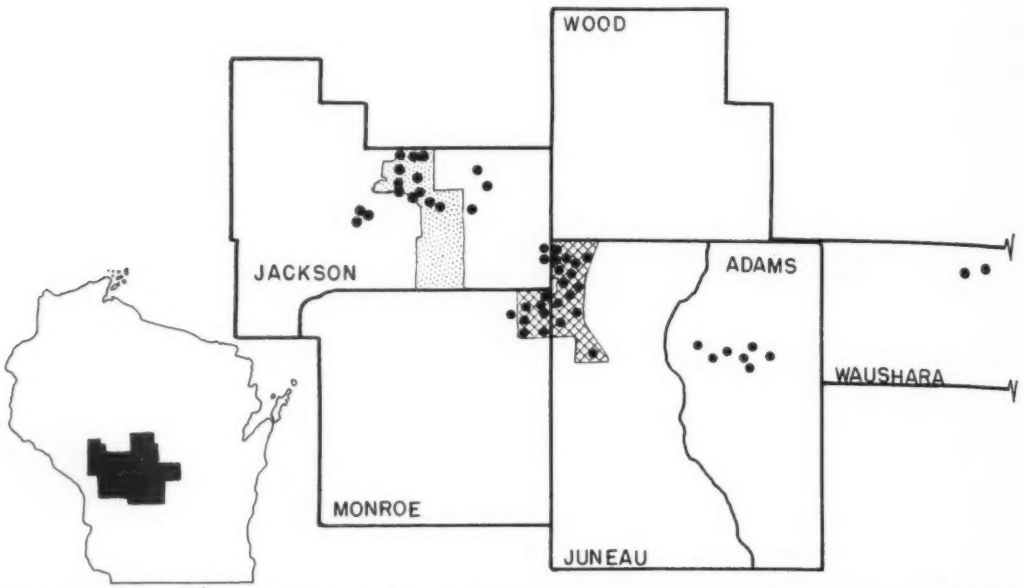

FIG. 1. Distribution of study areas in central Wisconsin. Each dot represents one stand. The Black River State Forest is outlined in Jackson County, and the Central Wisconsin Conservation Area is located in Juneau and Monroe counties.

communities. With the advent of settlement in central Wisconsin, the merchantable pines were cut, and agriculture was attempted on much of the land. The marshlands were drained for agricultural purposes; and uncontrolled fires, which maintained the native prairies and openings, were effectively stopped. As a result of the low productivity of the land, nearly all agricultural activity in eastern Jackson County and northern Juneau County was abandoned in the 1930's. Much of the abandoned farmland is currently reverting to the native forest vegetation. With continued fire protection, the prairies and openings not involved in agricultural usage in recent years are also returning to forest.

METHODS

As it was desirable to study a wide range of forest-community types and also areas that were representative of varying degrees of winter deer activity, the stands were chosen subjectively. The majority of the forested area in central Wisconsin now consists of pure stands or varying mixtures of jack pine (*Pinus banksiana*) and scrub oak (*Quercus ellipsoidalis*). It was difficult to locate red pine and white pine communities, and stands composed of red oak (*Quercus rubra*) and red maple (*Acer rubrum*). An additional problem in the selection of stands involved the classification of the degree of winter deer activity. The boundaries of the deer wintering areas in central Wisconsin are not as well defined as the lowland deer yards in northern Wisconsin (Christensen, 1954); the entire central Wisconsin area serves as winter deer range to some degree. It has been noted by local game managers, however, that some areas several square miles or more in size do possess more wintering deer than the surrounding area. There is no indication that such areas of higher deer concentration are topographically or vegetationally discrete from the areas of low concentration. With the aid of Wisconsin Conservation Department personnel familiar with the central Wisconsin deer range, sufficient information was gathered to classify broad areas as being lightly used or heavily used by deer during the winter. With this degree of separation, it was possible to make comparisons between the level

of deer activity and the behavior of the ground-layer browse species.

Data were collected from 40 forest communities in Jackson and Juneau counties and portions of northeastern Monroe County. A few of these study areas fall outside the boundaries of the state-owned tracts. In addition, the data from nine stands studied in nearby Adams and Waushara counties (Brown, 1950) were incorporated with the data collected in this study.

The field methods used in this study needed to be rather rapid and accurate, as well as usable by a single operator. In sampling the tree vegetation, the quarter method, as described by Cottam and Curtis (1956), was employed. A total of 20 sampling points was studied in each stand. The resulting frequency, density and dominance for each tree species were summed to give importance values (Curtis and McIntosh, 1951). Estimates of the percentage of the canopy cover of the trees were made in each of the four quarters at each of the 20 sampling points, resulting in the tabulation of 80 canopy estimates in each stand, which were later averaged for each stand. Frequency data were collected for the ground-layer species by recording their presence or absence in a meter-square quadrat constructed at each of the 20 sampling points in each stand. While these data were being collected, a running compilation of the total flora was made, resulting in a presence list of all the species found in the stand.

The arrangement of the central Wisconsin stands into a compositional order (Greig-Smith, 1957) was thought to be the best means of studying the phytosociological behavior of the ground-layer plants. The ordering of the stands was accomplished by using the understory vegetation as a basis. This method of community ordination, referred to as the Presence Index, was developed by Curtis (1955) as a means of describing the prairie communities in Wisconsin.

In adapting the Presence Index to describe the central Wisconsin forest communities, three groups of ten indicator species each were selected. These three groups consist of understory species that are known to be both common and characteristic of three plant community types (Curtis, 1959)—the prairie (*Andropogon Gerardi, A. scoparius, Antennaria* sp., *Coreopsis palmata, Comandra Richardsiana, Helianthemum canadense, Helianthus occidentalis, Krigia biflora, Lupinus perennis,* and *Lithospermum canescens*); the northern dry forest (*Anemone quinquefolia, Aralia nudicaulis, Arctostaphylos uva-ursi, Betula papyrifera* seedling, *Chimaphila umbellata, Cypripedium acaule, Diervilla lonicera, Epigaea repens, Melampyrum lineare,* and *Myrica asplenifolia*); and the northern mesic forest (*Brachyelytrum erectum, Clintonia borealis, Goodyera pubescens, Hepatica americana, Osmunda Claytoniana, Pyrola elliptica, Smilax herbacea, Smilacina racemosa, Trientalis borealis,* and *Viburnum acerifolium*). The dry-forest type refers to the northern Wisconsin red pine–white pine communities and the mesic forest refers to the northern Wisconsin upland-hardwood communities. The prairie is characteristic of southern Wisconsin.

In calculating the Presence Index for any given stand, the indicator species which are present in the stand are determined from the presence lists, and then the index numbers are arrived at by making a weighted average of the group values. The number of prairie indicators is weighted by 1, the number of dry-forest indicators by 2, and the number of mesic-forest by 3. The resulting Presence Index has a theoretical range of 100–300. If a stand has 7 prairie indicators, 4 dry-forest indicators, and 1 mesic-forest indicator, then

$$\frac{(7\times 1)+(4\times 2)+(1\times 3)}{7+4+1}=\frac{18}{12}=$$

$$1.50\times 100=150.$$

The Presence Index value for this stand is 150. A stand that only contains prairie indicators has an index value of 100, and similarly, a stand with an index value of 300 must possess mesic-forest indicators only.

The taxonomic nomenclature used in this paper follows that of Gleason (1952).

RESULTS AND DISCUSSION

The Presence Index value was calculated for all 49 central Wisconsin stands; the actual range of index values found was from 122 to 275. The usefulness of the Presence Index in the phytosociological ordination of plant communities has been demonstrated (Curtis, 1955), and it has been shown (Gilbert and Curtis, 1953; Curtis, 1955) that stand-presence data are as satisfactory in developing the Presence Index as species-frequency data. In my analysis, the portion of the Presence Index gradient between 100 and 275 has been partitioned into five segments of 35 units each; the average importance values of each tree species in each segment are given in Table 1.

The phytosociological order of the tree species along the Presence Index gradient represents a forest successional change from dry, open communities dominated by jack pine and scrub oak to more mesic and more shaded communities dominated by white pine and red maple. The relative position and importance of other tree species along this gradient can be interpreted from the data presented in Table 1.

Further analysis of community characteristics can be made along the Presence Index gradient. In regard to tree density, there is a definite increase from approximately 200 trees per acre in communities with prairie understories to about 350 trees per acre in stands with mesic-forest understories. This change in tree density is also reflected in the average percentage of canopy cover, with the communities with prairie understories possessing canopy covers between 35 and 45 per cent, while the more mesic communities have canopy coverage between 70 and 80 per cent.

The phytosociological behavior of the ground-layer species along the Presence Index gradient can be seen from the data presented in Table 2. Percentage presence and average frequency are given for each of five 35-unit Presence Index gradient segments. Bearberry and trailing arbutus are most prevalent in the stands with prairie and dry-forest understories. Partridge berry, pipsissewa, and shinleaf are increasingly common in stands with mesic-forest understories. Wintergreen, dewberry, and blueberry are common in all portions of the Presence Index gradient.

It can be generally concluded that the ground-layer species in central Wisconsin, with the exception of bearberry, show a tendency either to maintain themselves or to become more common as forest succession progresses. The stability of the browse supply is, in the long run, entirely dependent on how far forest succession will progress in this region. It is very probable that the ground-layer species will decrease if the central Wisconsin sand plain is capable of supporting at some time in the future a more mesic vegetation than red oak–white pine-red maple communities. The data in segment No. 5 of Table 2 indicate that some of the ground-layer species become less

TABLE 1.—AVERAGE IMPORTANCE VALUES OF TREE SPECIES IN EACH OF FIVE 35-UNIT PRESENCE INDEX SEGMENTS

SPECIES		PRESENCE INDEX SEGMENTS				
		1	2	3	4	5
Jack pine	(*Pinus banksiana*)	*132.9*	77.4	65.7	73.7	3.9
Scrub oak	(*Quercus ellipsoidalis*)	130.7	*136.8*	54.6	59.9	26.8
Trembling aspen	(*Populus tremuloides*)	0	0.8	*31.9*	12.2	13.6
Black cherry	(*Prunus serotina*)	0	0.9	2.1	*3.5*	2.3
White birch	(*Betula papyrifera*)	0.8	0.4	16.0	*19.6*	11.1
Red oak	(*Quercus rubra*)	0	0	14.2	*24.3*	11.8
Red pine	(*Pinus resinosa*)	3.1	19.3	13.9	*40.2*	11.7
Large-toothed aspen	(*Populus grandidentata*)	3.7	19.7	4.5	8.5	*24.7*
White oak	(*Quercus alba*)	9.4	14.1	34.0	5.6	*54.6*
White pine	(*Pinus strobus*)	10.4	29.1	32.7	37.1	*72.7*
Red maple	(*Acer rubrum*)	0	0	10.1	14.7	*62.2*

Table 2.—Percentage Presence (PP) and Average Frequency (AF) of Ground-layer Plants in Each of Five 35-unit Presence Index Segments

Species		Presence Index Segments				
		1	2	3	4	5
Bearberry	PP	41.7	40.0	0	14.3	0
	AF	6.0	4.0	0	2.1	0
Pipsissewa	PP	8.3	20.0	41.7	14.3	37.5
	AF	0.8	2.0	7.2	1.4	7.6
Trailing arbutus	PP	25.0	50.0	33.3	28.6	0
	AF	1.7	1.7	1.0	3.0	0
Wintergreen	PP	75.0	100.0	75.0	85.7	75.0
	AF	13.6	38.0	42.9	70.0	30.0
Partridge berry	PP	0	20.0	50.0	28.6	62.5
	AF	0	7.6	3.0	8.8	9.4
Shinleaf	PP	8.3	0	33.3	14.3	62.5
	AF	0.8	0	3.3	2.1	8.1
Dewberry	PP	41.7	70.0	50.0	85.7	100.0
	AF	5.1	15.0	20.8	47.1	25.0
Blueberry	PP	100.0	100.0	83.3	100.0	87.5
	AF	53.0	61.0	47.1	64.2	42.5

abundant in the most mesic stands that presently exist.

In regard to deer-range-management programs in the near future, the results of this study indicate that the ground-layer browse on the winter deer range in central Wisconsin will be maintained at present levels or will increase in amount. This conclusion is supported by the fact that the actual area presently covered by mesic vegetation is but a small fraction of the total forested area in central Wisconsin.

As shown by Table 3, the present levels of winter deer activity are, for the most part, not causing a decrease of the browse species. Many of the species actually show an increase in the group of communities that are heavily used.

Information gathered in this study on the modes of reproduction of these species helps to explain how these browse plants are able to maintain themselves. Nearly all of the ground-layer plants show some degree of vegetative reproduction, either by means of underground rhizomes or above-ground runners. As a result, these browse species often form clones. Clone formation is particularly well developed in wintergreen and dewberry, the two most common and most important ground-layer browse species in central Wisconsin; clones of these species may occupy up to 100 sq. ft.

Examination of approximately 300 excavated plants revealed that the white-tailed deer do utilize these species rather heavily. Wintergreen, in particular, is very heavily utilized as winter browse, but the present study indicates that very little damage is caused to the plant. It appears that wintergreen can be browsed repeatedly, and yet replace the lost stem tissue and foliage the following summer. Many of the side

Table 3.—Percentage Presence (PP) and Average Frequency (AF) of Ground-layer Plants in 19 Areas of Low Deer Activity and 21 of High Deer Activity in Central Wisconsin

Species	Low Deer Activity		High Deer Activity	
	PP	AF	PP	AF
Bearberry	21.0%	2.8%	23.8%	3.2%
Pipsissewa	15.7	0.4	9.5	0.7
Trailing arbutus	31.6	1.5	33.3	1.8
Wintergreen	89.4	37.3	95.2	48.9
Partridge berry	26.3	5.5	33.3	4.5
Shinleaf	21.0	0.6	9.5	0.7
Dewberry	42.1	16.9	76.1	30.5
Blueberry	94.7	52.9	100.0	67.4

branches, arising from the underground rhizome of wintergreen, take on a witches'-broom appearance as a result of new growth from axillary buds. These side branches ordinarily cease producing new foliage only when the rhizome becomes old and begins to decay. The pawing and scraping activities of the deer frequently break the runners of dewberry and partridge berry, but such breakage is not thought to be harmful to the plants and may actually increase the number of individual plants.

It can be generally concluded, therefore, that the present deer population in central Wisconsin is not inimical to the present level of winter browse, and there is an indication that the present deer activity may actually benefit these ground-layer browse species.

SUMMARY

A vegetational study was made of the central Wisconsin winter deer range to determine the present status of eight ground-layer species that comprise a large percentage of the winter deer browse in this area, and to check the observational hypothesis that the present level of winter deer activity is causing these ground-layer species to decrease in number. The data from 49 stands were arranged in a phytosociological order by means of a presence index, based on understory species only. It was shown that the trees were correlated with this presence index, and that the order represents a successional change from dry, open communities to more nearly mesic and more shaded communities. The results show that most of the ground-layer browse species in the central Wisconsin deer range are not decreasing as a result of forest succession. A study of the modes of reproduction of these browse species indicates that most of them possess the ability to reproduce vegetatively from rhizomes or runners. These plants can withstand very heavy browsing. The disturbance of the rhizomes and runners by deer activity may lead directly to an increase in the number of the plants.

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GROWTH AND PLUMAGE DEVELOPMENT OF WILD-TRAPPED JUVENILE CANVASBACK (*AYTHYA VALISINERIA*)[1]

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This paper discusses weight and plumage changes of the canvasback from hatching to fledging. It includes descriptions and measurements presented with the object of facilitating age determination. Data on 122 known-age young captured during the summers of 1952–55 on a 4-square-mile study area, 9 miles south of Minnedosa, Manitoba, are compared to measurements taken on a small number of spring-trapped adults in 1955 and 1956.

Means of determining the age of young waterfowl are always necessary for the accumulation and understanding of the various kinds of data relating to reproductive success. Much interest has developed during the last 5 years in the age classification of broods (Blankenship, 1952; Blankenship, Evans, Hammond, and Hawkins, 1953; Southwick, 1953; Weller, 1957; Schroeder, 1957). Field workers have found it imperative to determine more exactly the hatching peaks of species for a better appreciation of productivity data, hatching successes, and banding results. The present paper should make aging and back-dating of canvasback broods much easier for field personnel.

I wish to thank H. Albert Hochbaum for directing the study in Manitoba and for advice on the manuscript. Charles D. Evans, Rex Tice, William H. Kiel, Don Krieble, and Arthur S. Hawkins of the U.S. Bureau of Sport Fisheries and Wildlife helped in many ways. Robert B. Klopman took most of the photographs and assisted in trapping young. My appreciation is also extended to Peter Ward, Fred Ross, David A. Munro, J. Bernard Gollop, R. Tom Sterling, Robert A. McCabe, and Joseph J. Hickey for critical advice regarding this manuscript.

Materials and Methods

During a study of canvasback brood mobility, I injected clutches with dye after a method described by Evans (1951), i.e., 0.26–0.42 ml. of green or red dye solution 2–11 days before hatching. However, my procedure was somewhat different from Evans', as most clutches were injected with a double dose of dye 1 day before hatching or exactly at pipping time. I found hatching success to be much higher if the dye was injected late during the incubation period rather than a week earlier. Colored broods that moved beyond the confines of the study area were trapped, weighed, and measured. Partially colored broods were followed to determine size of brood ranges, age to flying, and days in each plumage class. A Hawkins-type drive trap (Addy, 1956) was used to catch young for examination, and cannon-projected nets (Addy, *ibid.*) were used to capture adults.

Of the 122 young examined, 66 were males and 56 were females. Because of the small size of the sample, I am not separating mean class weights and measurements of the two sexes in this paper.

Twenty-seven adults, 18 males and 9 females, were trapped during the spring, and five females were collected in June. A collection of 63 young of unknown age but representing all plumage classes was made, and 38 study skins prepared. These skins are filed in the collection of the Canadian Wildlife Service at Saskatoon. Eight young that could just fly were caught and measured in August 1954, and 10 immature birds of unknown age were collected in September 1956.

[1] Contribution from the Delta Waterfowl Research Station; the Dept. of Forestry and Wildlife Management, University of Wisconsin; and the Canadian Wildlife Service. Financial aid was received from each of the above institutions. The National Research Council of Canada provided grants for summer equipment and a special scholarship to study at the University of Wisconsin for 1 year.

I have not attempted in this paper to parallel the more detailed work of Weller (*op. cit.*) on growth, weights, and plumages of the redhead (*Aythya americana*). The present paper is concerned mainly with body-weight changes, juvenal-plumage classes, and growth of culmen and tarsus.

Study Area

The study area was in the pothole–parkland habitat of Manitoba, the same area used by Evans, Marshall, and Hawkins (1954), and described in detail by Kiel (1955) and Dzubin (1955). Shallow sloughs (potholes), most of which were less than 6 feet in depth, with grain fields between, made up the greater portion of the habitat. The main emergents in the potholes were white-top (*Scolochloa festucacea*), sedge (*Carex* spp.), cattail (*Typha latifolia*), bulrush (*Scirpus acutus, S. validus, S. paludosus*), spikerush (*Eleocharis* sp.), and rush (*Juncus* sp.). On the study block, 45 permanent water areas, varying in size from 0.8 to 12.0 acres, were most commonly used by canvasback with broods. The young were usually found on cattail and bulrush potholes containing water deeper than 1½ feet.

Weights and Measurements Taken

Weights were taken with a standard Ohaus triple-beam balance accurate to within 0.5 gm. Birds were usually placed in a small sack to prevent undue movement while being weighed. Measurements of exposed culmen, tarsus, ninth primary, sixth secondary, longest scapular, and middle tail feather were taken on all birds. Other measurements occasionally taken included wing chord, total length, and swim length, i.e., distance from the front of the breast to the end of the tail feathers when the bird is in a swimming position. Measurments were taken as proposed by Baldwin, Oberholser, and Worley (1931). Wing measurements were taken after the wing was pressed flat on a ruler, while scapular lengths included the distance from the first scapular feathers to the end of the longest feather. The culmen measurement was from the first feather of the forehead to the bill tip. The tarsus included the tarsometatarsus and the condyles of the tibiotarsus and digits.

A plastic ruler was used to measure body parts and plumage. The method is not error-free, but is much faster than using dividers. Variations in length of plus or minus 1–3 mm. were noted in measuring primaries, secondaries, and tail feathers. Variations of plus or minus 5 mm. were noted on scapular measurement.

The weights and measurements reported in this paper are chiefly of young birds taken from dye-colored broods for which the hatching date was known. However, because of the individual variation between broods and the small sample in some plumage classes, the growth-rate charts (to be presented later in this paper) are scatter diagrams with no attempt at further refinement. Means are taken of whole plumage classes, including both males and females, even though males tend to average more in size.

Blake (1956) and Norris and Johnston (1958) have outlined many of the factors involved in variation in bird weights. Blake (*op. cit.*), in his comments on the diurnal variation in weight shown by certain passerines, found that the feeding pattern leads to a maximum weight during the afternoon and minimum in the early morning. He also discusses seasonal, individual, random, and geographical variation. In the present study, most of the birds were caught between 9 A.M. and 5 P.M. No account has been taken of the effect of feeding behavior on weight variation, as I have observed young feeding throughout the day, with especially active feeding periods during the early morning and evening. Veselovsky (1951, 1953), quoting some earlier work, mentions that the most important periods for growth of duck flight feathers are the daytime and the first night hours, i.e., the period of favorable feeding conditions. At night he found a complete interruption of flight-feather growth.

Plumage Classes of Juveniles

Age and plumage classification of broods was initially attempted by Stoudt (1938),

whose division of young broods into three classes was later expanded and refined (Blankenship, *op. cit.*; Hochbaum, 1944: 103; Southwick, *op. cit.*; Blankenship, *et al.*, *op. cit.*). More recently, Gollop and Marshall (1954) have proposed a plumage classification, which has been widely used by field personnel, to catalogue seven groups: *IA*, bright ball of fluff; *IB*, fading ball of fluff; *IC*, gawky downy; *IIA*, first feathers; *IIB*, mostly feathered; *IIC*, last down; and *IIIA*, feathered flightless. Weller (*op. cit.*) used eight plumage classes including a *IIIB* class, i.e., feathered and fledged, in his discussion of redhead growth, and I have also used this class to denote young just able to fly. As outlined by Weller (*ibid.*), such classes broadly follow the birds' age in weeks. If mid-point ages of canvasback are taken by weeks, they generally follow the plumage classes. There is, however, a good deal of variation in the limits of ages in each plumage class (Table 1). As the approximate limits of ages of birds in each class reported here are taken from birds in the hand, variations in the field, especially under conditions of poor visibility, can be expected to be somewhat wider.

My grouping (Table 1), based on size, color of down, presence of certain feathers, length of feathers, weight of birds, presence and absence of down areas, etc., is almost identical to that presented by Gollop and Marshall (*op. cit.*), except that I have included the *IIIB* group. Some of the data utilized in the present paper were incorporated in their original presentation.

TABLE 1.—APPROXIMATE AGES OF JUVENILE CANVASBACK IN EACH OF EIGHT PLUMAGE CLASSES

Plumage Class	Approx. Age Limit in Days	Approx No. of Days in Class	Approx. Mid-point in Days
IA	1– 9	9	5
IB	10–18	9	14
IC	19–25	6	22
IIA	26–32	7	29
IIB	33–42	10	37
IIC	43–53	11	48
IIIA	54–65	12	59
IIIB	56–68	Flying	—

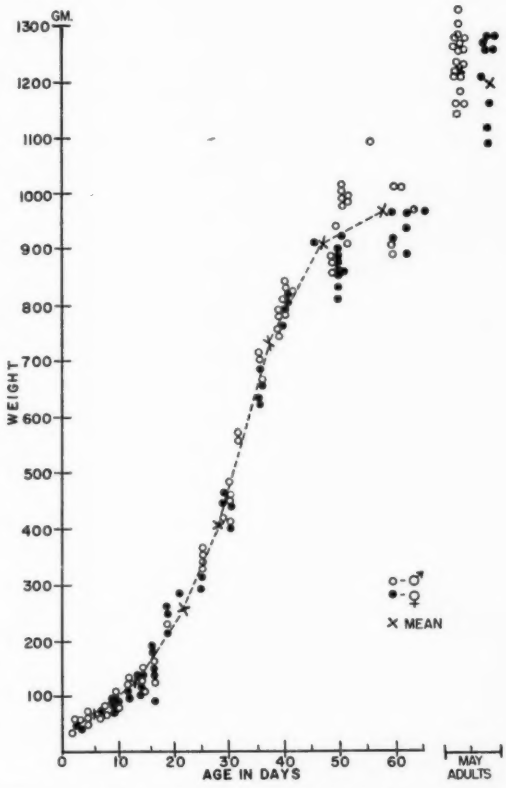


FIG 1. Body-weight changes in wild juvenile canvasback, compared to May weights of adults. Mean lengths of males and females in each plumage class are joined by the dotted line.

RESULTS

Age and Body-weight Changes

Weight of a brood of 10 newly hatched young averaged 44.7 gm., the five males averaging 44.8 gm., and the five females 44.6 gm. Other birds less than 5 days old varied from 35.8 to 59.4 gm. Body weight increased slowly for the first 2½ weeks, thereafter weight increased rapidly until a general slowing of the rise in the weight curve was seen at about 45 days of age (Fig. 1). Veselovsky (1953) noted that there were at least two knolls in the weight curve of several species of European diving and dabbling ducks. One occurs during the initial growth of the flight feathers, which he attributes to the large quantity of growth material needed for the flight feathers, and the second when the flight feathers are fully

grown and the duck just begins to fly. The initial drop in weight, which might occur in canvasback between the 35th and 45th days, was not indicated, possibly because of the small sample. The eight birds trapped just after flying stage was reached showed an erratic weight distribution, but averaged higher in weight than the young in class *IIIA* (Table 2).

The mean weight of five *IC* birds 19–22 days of age was 252.2 gm., while the mean weight of 22 *IIC* birds 45–53 days of age was 911.6 gm. (Table 2). Although the figures are somewhat distorted because only five early class *IC*'s were caught and most of the *IIC* birds were in the late stages of this class, the mean weights show that juveniles generally increase in weight from two to three times as fast between the fourth and seventh week as during the first 3 weeks. The major weight changes come in the *IIB* class with the 22 birds placed in this class varying in weight from 556 to 845 gm. If the approximate mid-point age is taken as the average of the class, there was a gain of 9.5 gm. per day between 1-day-old juveniles and those 22 days old (*IC*), while the gain from 29 (*IIA*) to 48 days (*IIC*) was 26.9 gm. per day.

Weights of five adult brood hens, included in order to make subsequent size comparisons, averaged nearly 100 gm. lighter than nine May-trapped females that were probably laying (Table 2). I have preliminary data suggesting that female canbasback lose considerable weight during the incubation period and slowly gain it in the brood period—a phenomenon similar to the seasonal variations reported in redheads by Weller (*op. cit.*).

Individual Variation in Weight

Weights of individuals varied from 43 to 48 gm. in a newly hatched brood of 10; from 88 to 104 gm. in a 9-day-old brood of 9; and from 919 to 1,039 gm. in a 50-day-old brood of 8. After juveniles have reached class II, there is some indication of a weight difference between sexes, with males averaging heavier. However, there is some overlap between light males and heavy females in every brood, and certain broods may average heavier than other broods of the same age (Fig. 1).

The relationship between weight and plumage development is not clear. I have preliminary data on canvasback and also mallards (*Anas platyrhynchos*) that show wide variations in weight among birds in the same plumage class. Little is known of the effect of food availability in brood sloughs on weight of young and speed of plumage growth. Some thought should be given to these relationships in future studies.

TABLE 2.—MEAN WEIGHTS AND BODY MEASUREMENTS OF CANVASBACKS

AGE OR PLUMAGE CLASS	NUMBER OF INDIVIDUALS STUDIED	WEIGHT (gm.)		TARSAL LENGTH (mm.)		CULMEN LENGTH (mm.)	
		Mean	Stand. Error	Mean	Stand. Error	Mean	Stand. Error
1 day	10	44.7	0.5	26.1	0.35	17.1	0.23
IA	18	69.2	5.3	28.3	0.61	19.0	0.58
IB	18	133.1	5.8	34.1	0.41	26.5	0.47
IC	5	252.2	10.6	40.2	0.49	31.2	0.66
IIA	15	400.5	16.0	48.1	0.26	39.6	0.65
IIB	22	732.5	18.8	53.2	0.35	48.1	0.52
IIC	22	911.6	13.8	54.9	0.20	54.3	0.34
IIIA	12	960.0	16.9	55.5	0.27	55.8	0.90
IIIB	8	992.8	6.5	55.8	0.23	56.4	0.37
Imm. Sept.	10	1,076.0[1]	12.2	54.8[1]	0.33	55.6[1]	0.34
Ad. May ♂	18	1,238.4	12.4	56.0	0.25	60.0	0.67
Ad. May ♀	9	1,216.6	25.9	54.1[2]	0.44	56.2[2]	0.62
Ad. June with broods	5	1,115.0	—	—	—	—	—

[1] May be distorted due to group being mostly hens.
[2] Includes both May and June measurements.

Tarsus and Culmen Measurements

The tarsus, averaging some 26.1 mm. in 7-day-old birds, was found to grow rapidly until the bird was approximately 40 days old and then to increase more slowly in size (Fig. 2). Tarsal lengths at 7 and 8 weeks did not vary markedly from those of adults. Weller (*ibid.*) concluded that the tarsus of juvenile redheads reached full size when the bird was in its sixth or seventh week.

The culmen was observed to grow much faster in canvasback than did the tarsus. Culmen increased in length from an average of 17.1 mm. at 1 day to 48.1 mm. at 5 weeks (Fig. 3), an increase of 31 mm., while tarsi increased only 27.1 mm. in the same time. Culmen growth proceeded rapidly from the first day until the 50th day. After that, only a small increase in length was noted until birds could fly. However, the mean culmen length of adults was 1–2 mm. longer than in *IIIA* and flying immature birds, indicating that the culmen goes on growing after the flying stage is reached. Weller (*ibid.*) points out that culmens reached nearly full size at about the 10th week in redheads, 1–2 weeks after they had reached flying stage, and full size by 16 weeks.

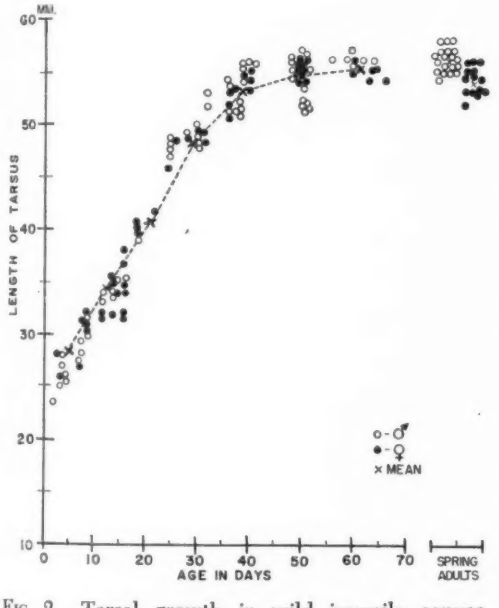


FIG. 2. Tarsal growth in wild juvenile canvasback, compared to measurements of adult birds. Mean lengths of both males and females in each plumage class shown in Table 2 are joined by the dotted line.

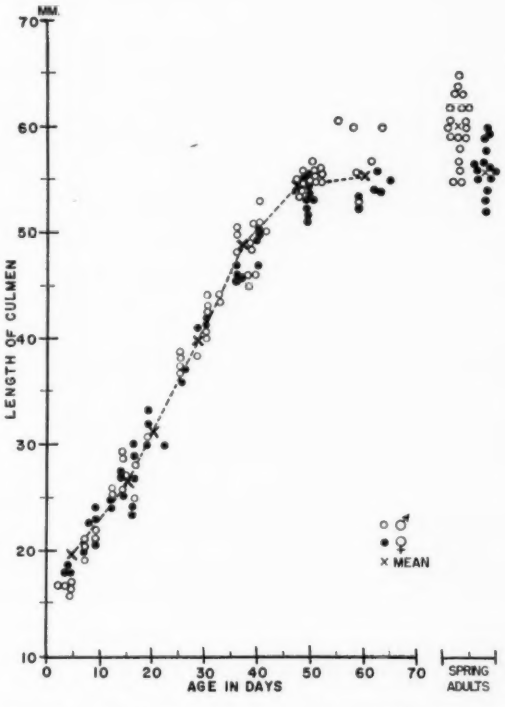


FIG. 3. Culmen growth in wild juvenile canvasback, compared to measurements of adult birds. Mean lengths of males and females in each plumage class are joined by the dotted line.

Total Length, Wing Chord, and Swim Length

Total length increased fairly constantly until the seventh week was reached, after which the increase was slower (Table 3). Total length and the general size relationships between young and brood hens is a good criterion for aging broods in the field (Fig. 4). Total length of September immatures was nearly 10 mm. less than adult females and approximately 40 mm. less than adult males.

Wing-chord measurements averaged 29.2 mm. for ten 1-day-old birds and had not changed materially by the 16th day when five averaged 31.0 mm. By the 19th day, four averaged 36.0 mm., while by the 30th day seven averaged only 56.9 mm. There-

TABLE 3.—RATIOS OF ADULT TO JUVENILE BODY MEASUREMENTS AND WEIGHTS[1]

Age or Plumage Class	Approx. Body Length	Approx. Swimming Length[2]	Ratio of Swimming Length to Adult ♀'s	Ratio of Weight to June ♀'s[3]
1 day	158	95	1:3.1	1:25.0
IA	197	110	1:2.7	1:16.1
IB	242	145	1:2.0	1:8.4
IC	305	175	1:1.7	1:4.4
IIA	352	205	1:1.4	1:2.8
IIB	418	235	1:1.3	1:1.5
IIC	487	255	1:1.2	1:1.2
IIIA	496	270	1:1.1	1:1.1
IIIB	509	280	1:1.1	1:1.1
Imm. Sept.	514	285	1:1	1:1
Ad. May ♂	552	310		
Ad. May ♀	520	295		

[1] Lengths taken from only 5 to 10 individuals in each class.
[2] The approximate distance between the front of the breast and the end of the tail when the bird is in a swimming position.
[3] Data from Table 2.

after, wings increased in size from approximately 89 mm. at 36 days to almost 200 mm. at the flying stage. After primaries broke through the quill sheaths at about 40 days, all wing measurements were greater than 85 mm. The wings of five spring-caught males averaged 241 mm. and five females averaged 227 mm.

Swim length is a crude measurement, but it gives a basis for comparing lengths of juveniles and hens and is useful in classifying broods in the field (Table 3). One-day-old birds had a swim length one-third that of adult hens; that of *IIA* birds was two-thirds as long; and that of *IIIA* juveniles, nearly as long.

Rectrices, Primaries, Secondaries, and Scapulars

The growth of scapular, primary, and tail (Fig. 5) was nearly identical to that described by Weller (*ibid.*) for redheads, except that average lengths were a little longer in canvasbacks. Some overlap of feather lengths between age classes occurred. Also, some juveniles had a few weight and plumage characteristics of two classes, but I have included them in one class only. Weller's (*ibid.*) description of the sequence of feathering and Veselovsky's (1951, 1953) descriptions of tufted duck (*Aythya fuligula*), ferruginous duck (*A. nyroca*), and pochard (*A. ferina*) feathering are very similar to that in the canvasback.

Rectrices grew approximately 2 mm. per day to reach a near maximum size at 7 weeks, while primaries increased in size nearly 5 mm. a day until flying stage. Secondaries grew at 3 mm. a day, and scapular growth was nearly 3.5 mm. per day until flying stage.

Sexes were differentiated in the hand by plumage as early as the 30th day. Males tended to have lighter scapular feathers that included gray vermiculations. Females' scapulars were darker, and only the intrascapular region became slightly vermiculated with gray in the oldest immature females. As shown in Fig. 4, the *IIIA* male can readily be distinguished from the darker-appearing *IIC* female. The head and neck region of *IIC* and *IIIA* males was dark cinnamon to buffy brown, rather than the light sepia to light buffy brown of females. In favorable light conditions, the latter difference, together with the grayness of males' scapulars, can be successfully used to sex broods in the field.

PLUMAGE CLASSES

To facilitate field aging of broods, both for birds in hand and broods on water areas, a description of size, color, and feathering of young is presented. A series of six photos of young canvasback of known age accompany the descriptions (Fig. 6). Each photo is given as an example of a plumage class and does not necessarily show all of the plumage characteristics described. The plates should aid field workers in establishing general sizes and plumage patterns. Exact age of the juvenile on the plates is indicated by the bracketed number of days after the plumage class. No photo is given for the *IB* class.

Minor color differences occur among birds of the same age. The colors indicated have been taken from five to seven study skins and varying numbers of live young in the

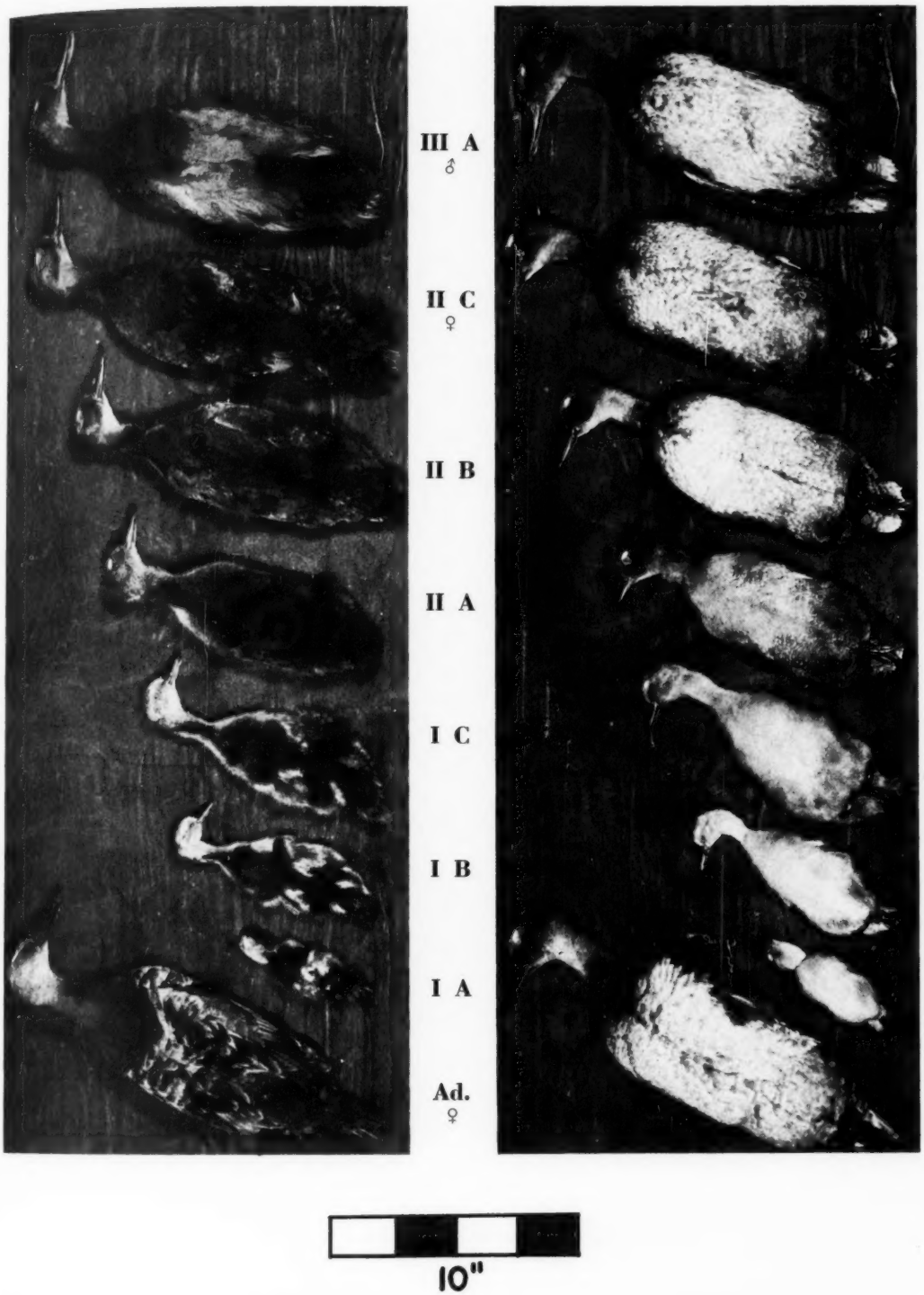


FIG. 4. Dorsal and ventral views of adult female canvasback and seven young in various plumage classes showing size changes and sequence of feathering. Note gray vermiculated *IIIA* male.

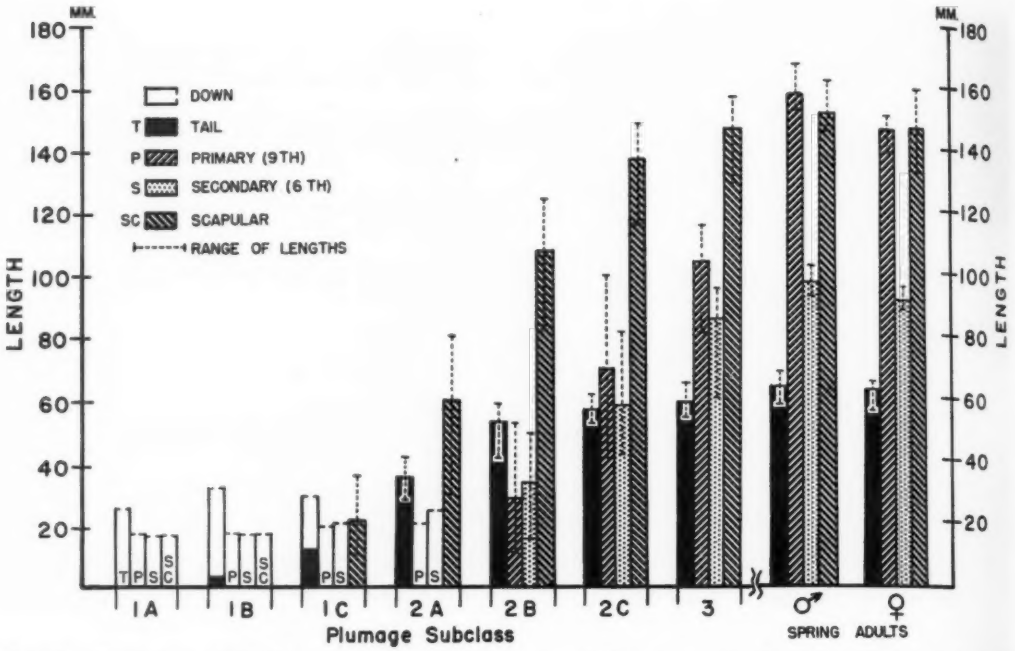


FIG. 5. Growth of juvenile rectrices, primaries, secondaries, and scapulars. Comparison is made with spring-trapped adults.

field. Colors used are from Palmer (1955) and Palmer and Reilly (1956).

IA (4 days).—Yellow to straw-yellow down areas are bright on the belly, breast, and cheeks. Two small yellow areas are found on the sides of the rump, several uneven ones on the upper flank and scapular region, and a yellow band on the lower edge of the wing. There is a marked contrast between the yellow down and the light olive down areas of the back and head. The body shape is rounded. *Key field indicators*—very small size and bright down. Ratio of birds' swim length to brood hen is about 1:3.

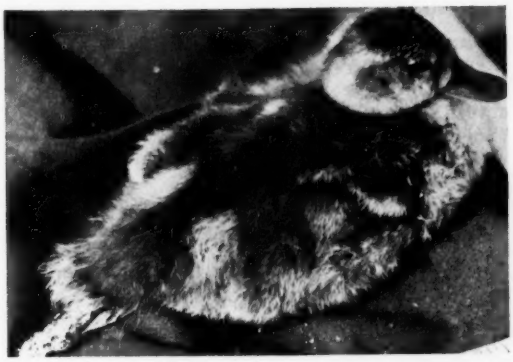
IB (no photo).—Yellowish down areas are faded to a light straw yellow and darker areas faded to a light sepia or light olive. Cheek patches and under wings may still be bright. Tail begins growth with first rectrices pushing the down outward. Older juveniles appear elongated and elliptical in shape. *Key field indicators*—faded down, elliptical shape, and prominent tail. Ratio of birds' swim length to brood hen is about 1:2.

IC (22 days).—Yellow under-down areas are faded to a pale straw yellow. Darker areas are faded to a dark buffy brown or pale sepia. Elongated rectrices with down attached to end are noticeable, as is a dark auricular area. In hand, the first scapular and flank feathers can be noted as early as the 19th day, and in the field these areas appear darker as the feathers push through. *Key field indicators*—large-appearing, faded, downy young; body definitely elongated; tail prominent. Ratio of birds' swim length to brood hen is about 1:1.7.

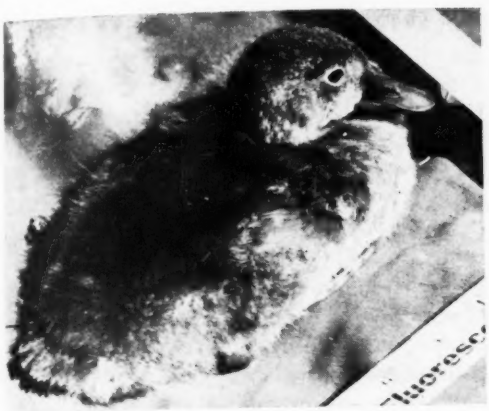
IIA (29 days).—Dark-appearing with light straw-yellow down mixed with a pale straw-yellow down on the upper breast, neck, nape, and cheek region. The belly may or may not be completely feathered, as loss of down proceeds from the lower belly forward and from the mid-line out. The belly is brownish olive at rear, fusing into smoke gray on the middle and into the upper breast. The feathers are tipped with white or pale gray. Some bellies appear nearly pure white or flecked with light gray on the surface. Cheeks and part of flank feathers are light buffy brown. Rectrices are distinct with no down on end. Flank feathers are elongated and scapulars distinct. Scapulars are brownish olive in females and vermiculated dark gray or smoke gray in males. First tertials have broken through their sheaths and are visible if bird is in hand. In some 5–7 days, bird becomes *IIB* as pale straw-yellow down wears off chest, neck, and most of head. *Key field indicators*—head, back, breast, and sides are mostly covered with down; tail, scapular, and flank feathers distinct; yellow down present on breast and neck. Ratio of birds' swim length to brood hen is about 1:1.4.

IIB (41 days, ♂).—Elongated down areas are evident on the intrascapular or mantle regions, as feathers push the down out. Upper tail coverts are nearly complete, but area of down extends up center of back to nape. Under tail coverts are complete,

4 days (class IA)



22 days (class IC)



29 days (class IIA)

41 days (class IIB--♂)

48 days (class IIC--♂)

56 days (class IIIA--♂)

FIG. 6. Examples of known-aged young from six plumage classes.

with some white tipped. A few pale straw-yellow down areas may be evident on cheek, neck, and nape in early *IIB* birds. Flank feathers are elongating and nearly cover the back flank area. Upper breast fuscous with belly whitish and flecked with light-gray and smoke-gray areas, while rear belly area is a light brownish olive. Head and cheeks are a light buffy brown in both males and females, with

males being somewhat paler. Scapulars of males are smoke gray in some and medium gray in others. In males, pale gray vermiculations on the scapulars are evident. Females' scapulars are a dark brownish olive. Some sheathed secondaries appear by the 33rd day, and sheathed primaries appear a little later. Primaries break through sheaths by the 38th day, while at this time secondaries may be up to 50 mm. long. Alula feathers break through their sheaths. Long tertials and a pale straw-yellow down area on rump are quite evident if bird is in hand. *Key field indicators*—bird nearly feathered and about three-quarters of the swim length of female; little or no pale straw-yellow down on breast or neck; scapulars and flanks not long enough to cover down areas of back and side. Wings, if visible, are short and sheaths of primaries distinct.

IIC (48 days, ♂).—Down area extends along mid-line of back but is seldom visible unless bird is in hand. However, some feathering extends up from upper tail coverts. Scapulars are elongating but still do not cover all of down area above rump. Primaries continue to grow. Upper wing surface is nearly all downy, with some small lesser, middle, and greater coverts showing above the secondaries and tertials. Alula feathers are elongating. Rectrices are complete. *Key field indicators*—bird appears nearly as long as hen or seven-eighths of hen's swim length (although female may be missing in some broods over 45 days of age). If light conditions ideal, small down area visible above rump. Sheathed primaries with feathers erupted and over 2 in. long can be seen if bird flaps wings.

IIIA (56 days, ♂).—The small area of down on the mid-back region is visible if bird is in hand. Primary and secondary coverts are growing and covering upper wing surface. Under lining of wing is nearly complete except for down area on patagium. Scapulars reach full length. In males the pale gray vermiculations extend down the scapulars and onto coverts of wing in contrast to the brownish olive of the females' scapulars and their slightly vermiculated, somewhat darker smoke-gray coverts. Speculum region is a light gray color. Secondaries, especially the last six, may be white tipped. Heads of some males are a distinctive dark cinnamon, while others tend toward a buffy brown, contrasting with the light sepia to light buffy brown on the females. Dark, blackish-gray flecking may also appear on the front cheek region of males. Mid-back region is a blackish gray above the upper tail coverts. White eye ring is quite distinct. Birds are completely feathered and nearly flying. Flight is attained when the quills of three to six of the primaries are still somewhat soft. Date of first flight varies with stimulus (i.e., wind, disturbance, presence of other flying young), as some birds will not attempt to fly before the 68th day. Part of the rump, mid-back, and under wing regions may still contain down in newly flying birds. *Key field indicators*—looks completely feathered and as large as hen, if present. Primaries appear complete but bird unable to fly.

DISCUSSION

The descriptions, photographs, and measurements presented should make backdating of canvasback broods more accurate, especially for determining specific ages of local young during banding drives and their use in subsequent banding analyses. With the bird in hand, quick measurements of culmen, 2nd primary, and 6th secondary, and reference to the plumage class will give a fairly accurate age.

Similarly, age data from routine brood surveys could be used to determine yearly hatching peaks of canvasback. However, it should be borne in mind that, unless light conditions are favorable and the brood is close at hand, there is likely to be some variation in the classification by different workers. During the summer of 1954, 62 canvasback broods of known age were classified by three persons familiar with waterfowl. In several instances, wide variations in distinguishing *IA* from *IB* classes and *IIB* from *IIC* classes were noted. Also, "gawky-downy" young in *IC* class were usually lumped as *IB* birds under poor light conditions.

Field classification of young canvasback is simpler than that for many dabbler species; canvasback usually keep to the center of sloughs, and invariably it is only the younger classes that retire into emergent vegetation. A good pair of binoculars, a pocketful of rocks, and a good pitching arm to scatter broods in order to observe growth of primaries or secondaries, down areas, etc., are indispensable aids in correct field aging.

Ages of broods, as determined from plumage characteristics, may vary between habitats, as they do between hatchery and natural conditions. Although Weller (*op. cit.*) found little difference in plumage characteristics and weights of wild-trapped and hatchery-raised redheads, this does not hold true for canvasback. At ages up to 4 weeks, weights of wild young that I recorded were approximately the same as those outlined by Southwick (*op. cit.*), but by 6 weeks the hatchery-raised young were 200–300 gm. lighter than wild birds. Plumage development was nearly the same except that

changes were somewhat more advanced in wild birds. As Southwick (*ibid.*) points out, down may wear off faster in wild birds, bringing them more quickly into advanced plumage classes. Some variation in growth rates is also borne out by comparison of the present data with the plumage changes and age characters outlined by Hochbaum (*op. cit.*:103), e.g., 63–77 days to flight stage for hatchery-raised young and only 56–68 days for my wild-trapped juveniles. Therefore, workers on special study areas might have to determine mid-point ages and variation in age of each plumage class before attempting to use them to determine hatching peaks critically.

SUMMARY

This paper describes the growth and plumage development of 122 wild-trapped canvasback of known age caught in the parkland habitat of south-central Manitoba. Sexes were not differentiated, even though the weights, and tarsal and culmen lengths of males appeared to be greater than females, especially after the third week.

From some 44 gm. at hatching, body weight of juveniles increased slowly for the first 2½ weeks; thereafter, it increased rapidly until about 45 days, when it slowed somewhat, and was nearly 1,000 gm. at flying stage (56–68 days). Tarsal lengths of 7- and 8-week-old young did not vary markedly from those of adult birds. The culmen grew faster than the tarsus. It increased in size rapidly from the first day until a tapering off was noted at the seventh week, but it appeared to grow slowly even after birds had reached flying stage. Because the culmen takes longer than the tarsus to reach maximum length, it is perhaps the best single criterion of approximate age of birds in hand. However, measurements presented herein on primary, secondary, scapular, and rectricial lengths should be used in conjunction with culmen and tarsus data in order to determine age more precisely.

Males can be differentiated from females as early as the 30th day by gray vermiculations on their scapulars. Males also tend to have a darker cinnamon head color than females, especially after the 45th day. The relationship between weight and plumage development may not be the same in different habitats or in the same habitat in succeeding years, due perhaps to differences in food availability. The ratio of weight of young to brood hen (1,115 gm.) varies from 1:25.0 at 1 day, 1:2.8 to 29 days to 1:1.2 at 48 days. The ratio of swim length of young to brood hen (295 mm.) is 1:3.1, 1:1.4, and 1:1.2, respectively. Both ratios can be used successfully to age broods in the field. Eight plumage classes (*IA, IB, IC*; *IIA, IIB, IIC*; *IIIA, IIIB*) are delineated, and young from each class are described in some detail.

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FACTORS INFLUENCING THE WINTER ROADSIDE COUNT OF COTTONTAILS[1]

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The roadside-count technique, as used to determine relative numbers of cottontails (*Sylvilagus floridanus*) in Iowa, provides valuable information for consideration in setting hunting seasons throughout the state. Indices obtained from such roadside counts provide comparative data on population fluctuations from area to area and from one year to another.

PURPOSE AND TECHNIQUE

This paper summarizes the results of an investigation that sought to determine the influence of weather conditions on the number of cottontails observed along two roadside count routes in good cottontail range in southern Iowa, the full results being given in detail by Newman (1957). A secondary objective was to determine and suggest improvements in the methods of obtaining roadside-count data, as recommended by Hendrickson (1939) and as now used in Iowa.

This study was conducted from January 1 to March 20, 1957, on an area in Wayne and Decatur counties in south-central Iowa. The 20-mile count routes were established on all-weather roads, one in each county. Counts were made on alternate mornings and evenings on the two routes. Morning counts were begun at 1 hour and 20 minutes before sunrise, while evening counts were started at 30 minutes before sunset. All counts were conducted from a car that was driven at the speed of 15–20 m.p.h. Cottontails were observed on the road, in the ditches, and in adjacent fields.

EFFECT OF TIME OF DAY

Of all rabbits observed, 70 per cent were seen during morning and 30 per cent during evening counts. The average number seen per 20 miles driven was 5.28 for 69 morning counts, while 58 evening counts produced an average of 2.69 cottontails, the differences being significant (Table 1).

More cottontails were seen along the middle 10 miles than on the first and last 5 miles of the route for the morning counts.

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TABLE 1.—COMPARISON OF THE NUMBERS OF COTTONTAILS OBSERVED DURING MORNING AND EVENING COUNTS

	A.M.	P.M.	Totals & Means
DECATUR ROUTE			
No. of cottontails seen	184	81	265
Percentage of day's total	69	31	100
No. of days counted	34	30	64
Mean no. counted per day	5.41	2.70	4.14
WAYNE ROUTE			
No. of cottontails seen	180	75	255
Percentage of day's total	71	29	100
No. of days counted	35	28	63
Mean no. counted per day	5.14	2.68	4.05

This peak in numbers toward the middle of the route probably indicates a period of greater activity of the cottontails and/or an increase of abundance of cottontails in that part of the count route. Evening counts showed peaks that were skewed toward the last 10 miles of the route, indicating (as one would expect) that, with decreasing light conditions, cottontail activity increases. However, to facilitate seeing cottontails adjacent to the road, it appears to be advantageous to start the evening count before complete darkness sets in.

COTTONTAILS ON AND OFF THE ROAD

The largest percentage of cottontails observed during the morning counts was seen on the road. For the evening counts, the greatest percentage was seen in adjacent fields (Table 2). The percentage of cottontails seen on the road in January was exceeded in both February and March. This tendency held true for both routes on both morning and evening counts (Table 3). It appears as if February and March represent a period of increased movement of the cottontail. Factors instrumental in this trend are mating activity and weather phenomena that differ from month to month.

I believe that the effect of certain weather factors causing vegetation to become damp influenced the number of cottontails seen on the road on the Decatur route during the morning count and in the adjacent field during the evening count on the Wayne route. This effect was due to vegetative differences of the two routes. The Decatur route had more woody, shrubby edge, making adjacent field observations more difficult on this route. Similarly, the greater abundance and heavy densities of vegetation along the Decatur route accounted for the larger percentages of cottontails seen on the road during morning counts along the route (Table 3).

EFFECT OF WEATHER FACTORS

The average number of cottontails seen increased sharply with increased snow cover (Figs. 1 and 2). In relation to the average number seen when no snow was present, the increase was greatest in the evening counts. For the two evening routes, the average number seen when over 1 in. of snow was present was 12 and 19 times the average

TABLE 2.—NUMBERS AND PERCENTAGES OF COTTONTAILS SEEN ON THE ROAD, IN DITCHES, AND IN ADJACENT FIELDS

ROUTE	TIME OF COUNT	ROAD		DITCHES		ADJACENT FIELDS		TOTAL	
		Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Decatur	A.M.	122	66	39	21	23	13	184	100
	P.M.	12	15	34	42	35	43	81	100
Wayne	A.M.	98	55	40	22	42	23	180	100
	P.M.	6	8	29	39	40	53	75	100

TABLE 3.—PERCENTAGE OF COTTONTAILS SEEN AT DIFFERENT LOCATIONS ALONG THE COUNT ROUTES FOR THE 3-MONTH PERIOD

Route / Time	Decatur A.M.	Decatur P.M.	Wayne A.M.	Wayne P.M.
JANUARY				
(Number of rabbits)	(76)	(57)	(101)	(50)
(Number of trips)	(13)	(9)	(14)	(8)
Road	42	4[1]	47	2[2]
Ditch	27	40	23	40
Field	21	56	30	58
FEBRUARY				
(Number of rabbits)	(71)	(9)	(50)	(23)
(Number of trips)	(12)	(12)	(13)	(13)
Road	79	89	70	17
Ditch	14	11[2]	18	35
Field	7	0	12	48
MARCH				
(Number of rabbits)	(37)	(15)	(29)	(2)
(Number of trips)	(9)	(9)	(8)	(7)
Road	92	13[1]	52	50[2]
Ditch	3[2]	67	27	50[2]
Field	5[1]	20[3]	21	0

[1] Representing two observations.
[2] Representing one observation.
[3] Representing three observations.

number seen with no snow present. On the morning routes, the average number seen when over 1 in. of snow was present was 2 and 3 times the average number seen with no snow present (Table 4).

Statistical analyses by linear regression show the correlation coefficients for cottontails observed and snow are significant at the 0.1 level for the evening routes. The larger r^2 values for the evening counts indicate that more of the variation in the number of cottontails seen can be associated with snow cover present, while on the morning counts, a lesser amount of the variation was associated with snow. Apparently other factors influence cottontail activity more during morning counts.

Morning counts indicate increases in the average number of cottontails seen from no frost through recordings of light and heavy frost (Tables 5 and 6). However, only 11 and 22 per cent of the variation in the numbers observed on the two routes could be associated with frost.

Correlation coefficients obtained from analyses of cottontail numbers in relation to

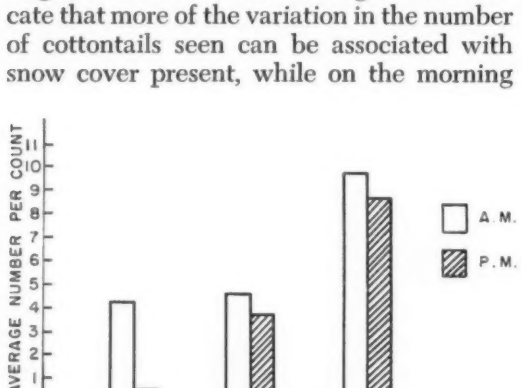

FIG. 1. Relationship of depth of snow to average number of cottontails seen per count on Decatur route.

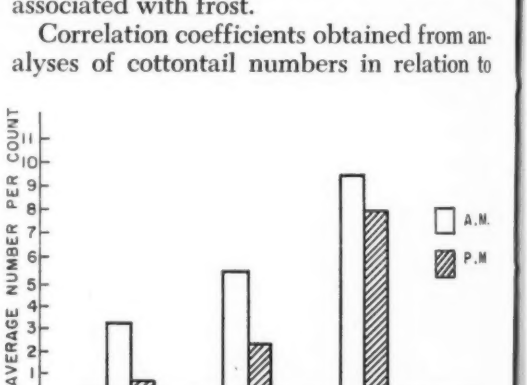

FIG. 2. Relationship of depth of snow to average number of cottontails seen per count on Wayne route.

TABLE 4.—COMPARISON OF THE AVERAGE NUMBERS OF COTTONTAILS SEEN WITH AND WITHOUT SNOW FOR THE COUNT ROUTES

ROUTE TIME	TOTAL NO. SEEN	AVERAGE NO. PER TRIP	AVERAGE NUMBER SEEN PER TRIP[1]	
			With Snow	Without Snow
DECATUR				
A.M.	184	5.4	8.6 (9)	4.3(25)
P.M.	81	2.7	7.2(10)	0.5(20)
Total	265	4.1	7.8(19)	2.6(45)
WAYNE				
A.M.	180	5.1	8.0(14)	3.2(21)
P.M.	75	2.7	6.3(10)	0.7(18)
Total	255	4.1	7.3(24)	2.1(39)
GRAND TOTAL	520	4.1	7.5(43)	2.3(84)

[1] The number of trips are shown in parentheses.

temperature were all negative. Temperature ranges encountered in this study were from -8° to +60°F., but only two subzero readings were recorded throughout the period.

The average number of cottontails seen when winds of 0–4 and 5–9 m.p.h. prevailed were both twice as large as the average number seen when winds over 10 m.p.h. were recorded for total morning counts.

No significant association was found between barometric pressure and the number of cottontails seen; however, a negative association is suspected. Three of the four correlation coefficients were negative in this analysis.

Heavy fog and/or light mist during the count, or rain preceding the count, increased the average number of rabbits observed. However, lack of a quantitative method of measurement of these factors, as well as

TABLE 5.—RELATIONSHIP OF FROST TO THE AVERAGE NUMBER OF COTTONTAILS OBSERVED ON MORNING COUNTS

Route Month	Total Seen	Per Count	With Frost	Without Frost
DECATUR				
January	76	5.85	8.14	3.17
February	71	5.92	6.60	5.43
March	37	4.11	4.00	4.17
WAYNE				
January	101	7.21	9.63	4.00
February	50	3.85	3.75	3.89
March	29	3.63	4.00	3.50

TABLE 6.—RELATIONSHIP OF FROST TYPES TO THE AVERAGE NUMBER OF COTTONTAILS OBSERVED ON MORNING COUNTS

Count Route	Type Frost	Number Days	Average Number Cottontails
Decatur	None	19	4.32
	Light	6	5.17
	Heavy	9	7.89
Wayne	None	21	3.81
	Light	9	6.00
	Heavy	5	9.20

paucity of data, made full analysis impossible. I feel that these factors do have a positive association with the number of cottontails observed.

No relationship was found between cloud cover conditions and the number of cottontails observed.

Multiple-regression analysis was employed in an attempt to determine the combined effect of weather factors. This method has the distinct advantage over simple linear-regression methods of determining how Y (cottontails seen) varies with each unit change in X_i (a weather factor, or variable), if all other X's (other weather factors or variables) are held constant. Coefficients of multiple correlation, R, for the two evening count routes were 0.911 and 0.841. Morning-count correlation coefficients were 0.555 and 0.663. From R^2 values, the conclusion can be drawn that 82.9 and 70.8 per cent of the variation in the evening cottontail counts was associated with weather factors. Only 30.8 and 43.9 per cent of the variation in morning counts was associated with weather factors on the two routes.

Snow used alone as the predictor variable is nearly as good as using all weather factors when one adjusts cottontail-count results. The other factors have contributed very little additional information (the r value obtained from rabbits seen with snow is nearly as large as the R value obtained from rabbits seen with all weather factors).

The partial-regression coefficients (b) are of interest since each b value is an estimate, based on the sample data, of the partial-regression coefficient of Y on X_1. These

values for snow do not differ greatly from corresponding b values obtained from simple linear-regression results of cottontails with snow. It seems logical, therefore, for practical purposes, to employ b values obtained from simple linear-regression results. Regression coefficients (b) indicate the change in the dependent variable (cottontails) per unit change in the independent variable (snow). Regression coefficients obtained were 1.18 and 1.17 for the morning routes and 2.23 and 2.35 for the two evening routes.

To adjust cottontail counts to different levels of snow, the formula for adjusted Y was used (Snedecor, 1956): *adjusted* $Y = Y_{obs.} - b(X_{obs.} - X_{adj.})$, where $Y_{obs.}$ = cottontails observed, b = regression coefficient obtained from data from the route on which the count is to be adjusted, $X_{obs.}$ = amount of snow present, and $X_{adj.}$ = amount of snow to which the adjustment is to be made. Suppose an evening count on the Wayne County route resulted in a count of 16 cottontails with 3 in. of snow on the ground (Newman, *op. cit.*). For adjustment to "no snow," the formula becomes, *adjusted* $Y = 16 - 2.35(3 - 0)$. Then $16 - 7.05 = 8.95$ or 9.0. The adjusted cottontail count for no snow becomes 9, or 7 fewer than the actual number observed (16). Similarly, counts may be adjusted to greater depths of snow, etc.

It should be remembered that the b values presented were derived from information gathered during one winter only. Additional data may increase or decrease the correction factor values somewhat. Certainly the correction or adjustment factors indicated for this study area would be unreliable if applied to counts from areas having other population densities. With this in mind, the importance of obtaining roadside counts when similar weather conditions (especially snow depth) prevail should be emphasized.

ACKNOWLEDGMENTS

I am indebted to Edward L. Kozicky, former Leader, and Arnold O. Haugen, Leader of the Iowa Cooperative Wildlife Unit, and to George O. Hendrickson, Department of Zoology and Entomology, for their guidance and constructive criticism; and to Emil H. Jebe, Iowa State College Statistics Department, for his assistance in the analysis and interpretation of the data. Computations of multiple regression and correlation were done by the Iowa State College Statistical Laboratory.

SUMMARY

On two 20-mile routes each traversed 64 times from January 1 to March 20 in south-central Iowa, the mean number of rabbits observed during morning counts was 5.3 and during evening counts 2.7. Cottontail activity decreases with increasing light conditions during morning counts and increases with decreasing light conditions during evening counts. Many weather factors influenced the number of cottontails observed, but snow was the most significant weather factor. Multiple-regression analysis indicated that 82.9 and 70.8 per cent of the variation in the evening counts can be associated with weather factors. Only 30.8 and 43.9 per cent of the variation in morning counts can be associated with weather factors on the two routes. The regression coefficients were computed and used to adjust the cottontail count to different levels of snow by means of Snedecor's (1956) formula for adjusted Y.

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EMBRYONIC AND FETAL DEVELOPMENT OF THE MULE DEER

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The Rocky Mountain mule deer (*Odocoileus h. hemionus*) is one of the important species of big-game animals in the western mountain states. The mule deer, like other big-game species, has been subject to an increasing amount of hunting pressure. A knowledge of the breeding habits and reproductive pattern is necessary if game-management agencies are to maintain the breeding stock successfully and yet provide a sustained yield for the hunter.

It seemed desirable to study the morphology of the embryonic and fetal development of the mule deer in order to augment our present knowledge of the reproduction of this species. Research involving mule deer reproduction was initiated by the Department of Zoology and the Montana Cooperative Wildlife Research Unit in September 1953, and material collected in this program was made available for the present investigation.

Materials and Methods

The deer used in this study were obtained from the National Bison Range at Moiese, Montana, where the number of deer in the herd are controlled so as to ensure more effective utilization of the range. The carcasses from which embryonic and reproductive material was obtained were processed and disposed of by the Bison Range management. The reproductive tracts with included products of conception and the internal glands of the does were made available to the Department of Zoology, Montana State University, and the Wildlife Research Unit.

The descriptive terms used in this study follow those used by Winters, *et al.* (1942). Embryology in its broadest sense usually denotes a continuous process of differentiation and growth from the formation of the zygote to parturition. The prenatal development does not exhibit any sharp

Table 1.—Measurements (in gm. and mm.) of Fetuses by Approximate Age

Sex and Age of Fetus	Weight	Length of				Shoulder Point			Head		Circumference of			Month, Day, and Year Coll.
		C–R or F–R	Foreleg	Hindleg	Contour	to Pin Bone	to Hip Bone	Shoulder Breadth	Height	Breadth	Medium Neck	Chest	Abdomen	
?s 48#	2.4	32.4												1/14/56
?s 50	3.9	38.7												1/6/55
?s 52	5.7	42.0												1/12/55
?t 57	11.3	59.2	22.1	20.5	112	34.8	27.9	12.5	21.9	11.6	28.0	50.0	58.0	1/6/55
?t 61	17.7	74.3	29.0	29.5	132	39.9	34.1	15.1	27.0	12.8	28.8	62.9	67.7	1/27/54
Mt 63	20.2	75.8	28.7	28.2	128	42.1	33.2	16.8	27.4	17.0	34.0	60.0	68.5	1/12/55
Ft 68	30.7	94.7	37.2	39.5	153	51.5	39.2	15.6	32.4	18.0	36.7	70.5	71.4	1/28/54
Ft 73	49.8	110.7	45.7	46.8	177	63.1	45.7	20.8	22.0	22.0	43.3	81.0	80.2	1/27/54
Mt 76	78.6	121.5	56.5	59.3	203	67.0	50.5	25.4	44.2	24.3	54.8	93.2	93.7	1/27/54
Ms 83#	111.2	142	59.8	63.2	212	79.5	59.1	25.6	49.5	28.4	63.0	104	110.5	3/10/56
Fs 86	168	155	73.9	79.1	257	87.0	67.2	33.7	57.0	31.2	57.6	124	130	2/13/54
Ft 89	233	164	77	84	286	93.5	69.5	36.0	61.8	34.6	66	133	139	2/14/54
Mt 111	545	232	127	141	382	139	107	48.8	86.4	44.8	106	173	175	3/13/54
Ft 117	677	252	143	157	424	146	110	48.6	92	48.7	107	188	199	3/22/54
Ft 137	1480	311	185	206	493	190	143	58.3	106	56.2	134	250	252	4/11/54
Ms 144#	1600	327	193	202	518	181	137	56.0	104	53.0	138	252	243	5/12/56
Ft 149	1800	353	224	240	495	217	154	63.0	122	62.5	138	255	218	5/14/54
Ft 161	2510	397	262	295	598	252	181	70.9	127	64.0	151	294	265	5/14/54
Fs 174#	2800	443	278	312	640	248	191	64.0	133	60.0	152	296	278	6/16/56

#—known age in days; ?—sex not determined; M—male; F—female; s—singleton; t—twin

points of demarcation. Three periods of prenatal development are arbitrarily chosen to facilitate discussion of different over-all periods of internal and external growth and differentiation:

1) The period of the ovum. The period from fertilization up to the time the blastocyst becomes attached to the endometrial wall of the uterus. This stage is not dealt with in the present study.
2) The period of the embryo. The period during which the main tissues, organs, and systems are formed; the typical flexures and rotation take place to produce successive changes of the body shape.
3) The period of the fetus. The period wherein the major changes noted are in external growth and development with the emergence of the external features of the species involved; up to the time of birth.

In this study, termination of the period of the embryo has arbitrarily been taken as about 48 days of age or 30 mm. in crown–rump length.

A total of 180 specimens was analyzed, including both embryos and fetuses. A series of 95 fetuses was obtained from a group used by Sears (1955) in a previous study. These specimens were preserved in either Bouin's fixative or AFA. Another group of 68 intact uteri was collected in November and December 1954 and January 1955. Eighty specimens obtained from this latter series and five known-age specimens obtained in 1956 were preserved in 10 per cent Formalin.

Following the system used by Armstrong (1950) and Winters, *et al.* (*op. cit.*), linear and circumferential measurements were taken, plus those of contour length, on all fetuses over 50 mm. in crown–rump length. Each specimen was placed on its right side with the back along a straight line and legs extended. The head was prevented from turning toward the tail, so that the position of each specimen was practically uniform when being measured. The bones of the skeleton or their discernible primordia were used as reference points in taking measurements, and no dissection was involved. It

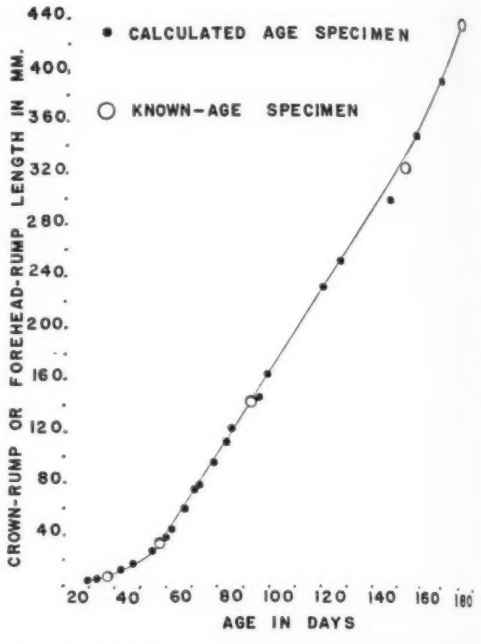

FIG. 1. Mule deer. Growth curve based on specimens of known age from does bred in captivity in Montana.

was recognized, however, that shape and appearance of external characters are of as great or greater value than measurements in determining age in early fetal development.

In order that the available specimens could be aged without resorting to a growth curve of another species, a project was carried out to obtain a series of known-age embryos. Fourteen marked does and one buck were placed in a corral approximately 130 ft. long by 45 ft. wide, with an isolation pen at one end for the buck. The buck was released only during daylight hours and was isolated at night. The buck was constantly observed while in the corral with the does, so that the known times of breeding could be noted. A review of this breeding program and the behavior of the penned deer is reported elsewhere (Browman and Hudson, 1957). Five known-age specimens were secured by sacrificing the does at designated intervals.

The approximate ages of the specimens of unknown age (Table 1) were then deter-

mined by locating the crown–rump (C–R) or forehead–rump (F–R) length of each on the ordinate of the growth plot (Fig. 1), drawing a straight line to the growth curve, and then dropping a perpendicular from this point on the curve to the abscissa representing the ages.

After the approximate ages were derived for a series of specimens, they were separated into two groups. One group (group I) consisted of embryos up to and including 30 mm. in C–R length and up to 3 gm. in weight. The other group (group II) ranged in size from 30 mm. in length up to and including 443 mm.

RESULTS

Growth Curves

The growth curve obtained from the known-age specimens (Fig. 1) resembles closely the growth curves obtained for white-tailed deer (*O. virginianus*) by Cheatum and Morton (1946) and by Armstrong (*op. cit.*), for oxen by Winters, *et al.* (*op. cit.*), and for sheep by Winters and Feuffel (1936). Although the derived growth curve for the mule deer is based on only five known-age specimens, its close similarity to the characteristics of the curves referred to above is considered adequate to warrant its validity for use.

The approximate ages of the fetuses in the series appearing in Table 1 were determined by use of the growth curve. The increase in length appears to be rather linear and steady from the late-embryo stage through most of the fetal period. Table 1 lists the measurements of 19 fetuses. A complete series of measurements of 114 fetuses has been tabulated by Hudson (1956).

The growth in weight is more rapid than the increase in length during the embryonic period and fetal period (Table 2).

The ratios of several selected measurements to F–R length were calculated (Table 2) and found to be of little practical value to the field man, with the exception of the ratio of weight/F–R (Fig. 2). For a comparison of the mule deer fetus with the white-tailed deer fetus, see Table 1 in Armstrong (*op. cit.*).

Table 2 and Fig. 2 indicate that the F–R and weight approach unity at about 85 days. When one uses the growth curve (Fig. 1), 150 mm. in F–R length corres-

TABLE 2.—GROWTH RATIOS

Age of Fetus (in days)	Wt./Age (gm./days)	F–R/Age (mm./days)	Ratios of				
			Wt.	Head Breadth	Chest Circum.	Abdom. Circum.	Foreleg Length
			to Forehead–rump Length				
48	0.05	0.68					
50	0.08	0.77					
52	0.11	0.81					
57	0.20	1.04	5.24	5.1	1.18	1.02	2.67
61	0.29	1.22	4.19	5.8	1.18	1.09	2.56
63	0.32	1.20	3.76	4.45	1.26	1.1	2.64
68	0.45	1.39	3.08	5.26	1.34	1.33	2.54
73	0.68	1.51	2.22	5.03	1.36	1.38	2.42
76	1.03	1.60	1.54	5.0	1.3	1.29	2.15
83	1.34	1.71	1.27	5.0	1.36	1.28	2.37
86	1.95	1.80	0.92	4.96	1.25	1.19	2.09
89	2.62	1.84	0.70	4.74	1.23	1.18	2.13
111	4.91	2.09	0.43	5.17	1.34	1.32	1.81
117	5.79	2.15	0.37	5.17	1.34	1.25	1.76
137	10.80	2.27	0.21	5.53	1.24	1.23	1.68
144	11.10	2.27	0.20	6.17	1.29	1.34	1.69
149	12.08	2.37	0.20	5.65	1.38	1.62	1.57
161	15.59	2.47	0.16	6.21	1.35	1.49	1.51
174	16.09	2.55	0.16	7.38	1.49	1.59	1.59

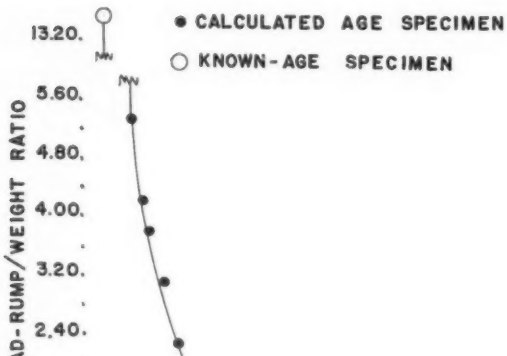

FIG. 2. Forehead–rump length on weight, and age on weight.

ponds to an age approximation of 85 days. A further check of the data reveals this estimate to be favorable. The head:breadth ratio holds fairly constant throughout the fetal period. Chest circumference is relatively larger at the 47- to 61-day stage, while the abdominal circumference is rather uniform with a slight decrease with age. The foreleg shows a steady increase up to approximately 144 days.

Growth of the auricles of the ears.—The auricles of the ear were first noticeable as small triangular projections at approximately 38 days of age (ca. 16–18 mm. in F-R length). The auricles at first were folded over in a lateral direction covering the external auditory meatus. The laterally folded auricles were measured from the fold to the distal tip. The auricles then unfolded and, extending mesially toward each other, were appressed to the dorsal portion of the head. This rotation of the auricles from the lateral

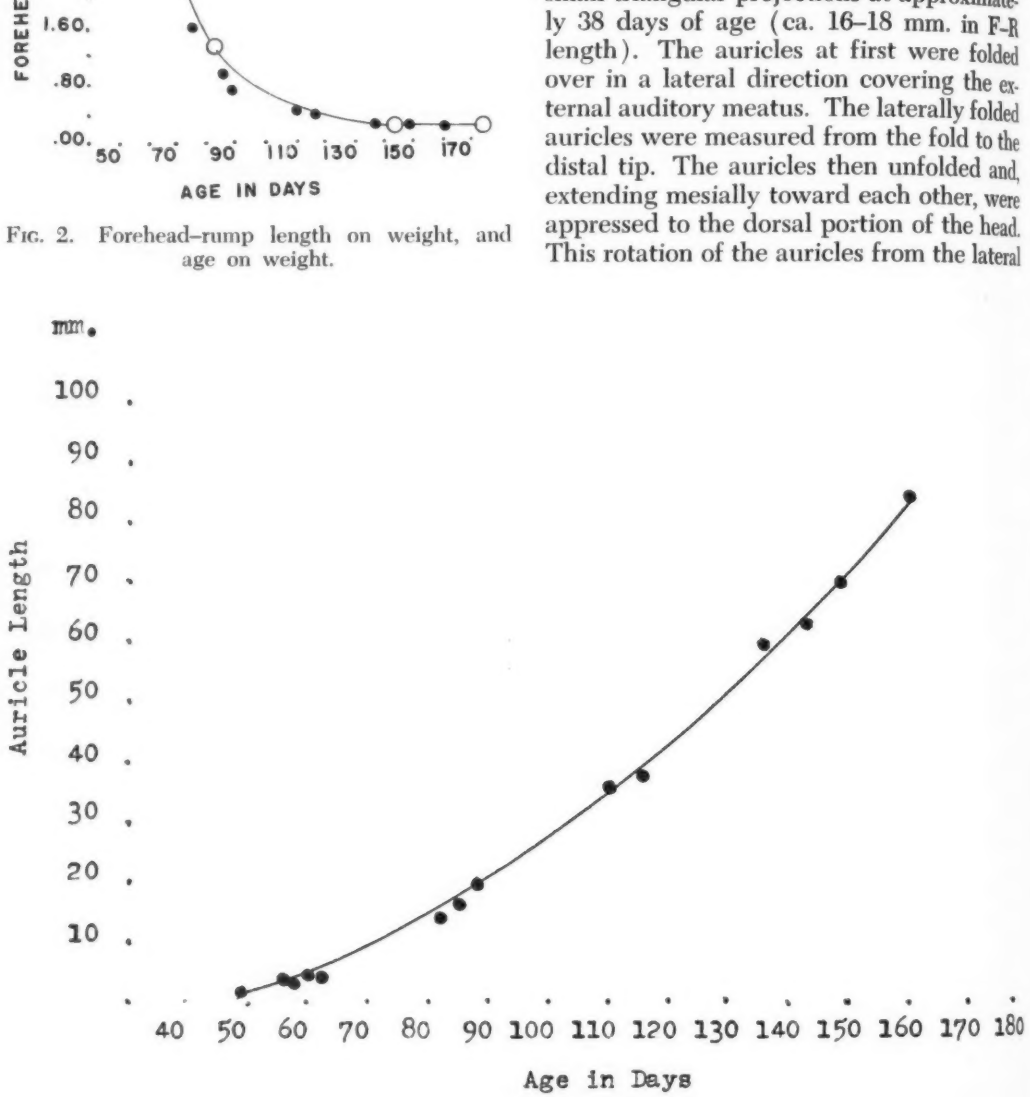

FIG. 3. Growth of the auricles of the ears.

to the mesodorsal position occurred at about 65–66 days, or 90 mm. in F–R length. The lengths of the auricles were now measured from the parietal crest of the temporal bone bordering the meatus to the distal tips of the auricles. The lengths of the auricles of a selected series of specimens, aged by C–R or F–R length, were then plotted to produce a curve of auricular length in respect to approximate age (Fig. 3).

Hindfoot length.—The hindfoot lengths of 19 selected specimens were recorded and then plotted in terms of the ages as calculated by using C–R or F–R length. A comparison of this growth curve of hindfoot length with the curve prepared by Chattin (1948) revealed that, up to 150 mm. in length, a comparable stage of development was reached 3 days earlier in the present study. Beyond 150 mm. in hindfoot length, the calculated ages of each curve markedly diverged (Fig. 4).

Breeding dates.—The estimation of the dates of breeding of 87 pregnant does was determined by use of the growth curve and collection dates. The age of the fetus or average age of multiple fetuses was determined by plotting F–R length on the growth curve (Fig. 1). The age of the fetus was then subtracted from the collection date to obtain the approximate date of breeding of the doe.

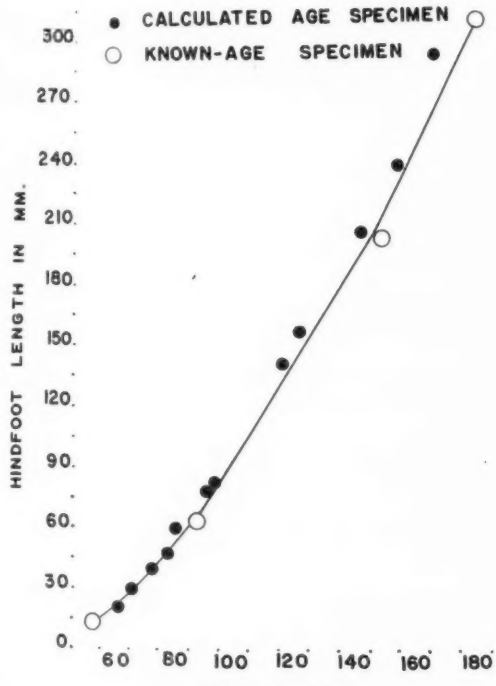

FIG. 4. Growth of hindfoot.

TABLE 3.—MEASUREMENTS OF MULE DEER EMBRYOS
(Age is approximated in all but two cases)

Specimen Number	Age (days)	Crown–rump Length (mm.)	Weight (mg.)
1	(20?)	(4?)	2.0
2	(24?)	(5?)	—
3	28°	6.6	7.6
4	30	7.7	50.6
5	32	9.8	186.4
6	33	11.0	218.7
7	34	11.9	232.2
8	35	13.6	351.2
9	38	17.0	443
10	45	26.9	2,000
11	48°	32.4	2,400

° Known-age specimen.

The average date of calculated breeding was November 20, with a standard deviation of plus or minus 7 days; 95 per cent of the calculated breeding occurred between November 10 and December 1, inclusive. The age determinations by tooth analysis of the does in this group were not available in sufficient numbers to allow for a breakdown into yearling and adult age classes.

The deer bred on December 17, 18, 20, and 26, respectively, produced the known-age embryos. These penned deer showed definite signs of coming into heat about the middle of November, but were disturbed at that time by activities connected with the slaughtering of bison (*B. bison*) adjacent to the breeding pen. These deer then may have had a recurring estrus in December.

Embryonic Development

A cursory examination of a series of group I embryos (Table 3) indicates the following major changes in shape and in development of visible external structures. The ages were determined by use of the growth curve (Fig. 1) and were, at best, approximations.

Twenty-day embryo.—Weight, 2 mg.; C–R length, 4 mm.; had rotated sinistrally approximately one-third of its length; the anterior neuropore was clearly visible in the elevated cephalic region; the small heart prominence was discernible; 12 pairs of mesodermal somites could be counted, but the fragility of the specimen discouraged excessive handling.

Twenty-four-day embryo.—Weight, unknown; C–R length, 5 mm.; this specimen was flattened dorsoventrally posterior to the cephalic region, and flattened laterally in the cephalic region; 20–21 pairs of mesodermal somites were counted; specimen not too well preserved and might possibly represent a resorbing embryo.

Twenty-eight-day embryo.—Weight, 7.6 mg.; C–R length, 6.6 mm.; lying on side, sinistral rotation completed approximately two-thirds of body length; caudal flexure almost complete; tail comes to blunt tip; cephalic flexure evident; cervical flexure not too well defined; approximately 31 pairs of somites; ventricle of heart well defined; small elliptical-shaped liver lies so that the tip of the ventricle projects caudad to the ventral edge of the liver; optic cup just visible; four branchial arches well demarcated; forelimb buds present as noticeable swellings; hindlimb buds barely evident; vertebral arch is not closed, and spinal cord is visible; mesonephros visible with reflected light; maxillary and mandibular processes just forming.

Thirty-day embryo.—Weight, 50.6 mg.; C–R length, 7.7 mm.; rotation complete, embryo lying on side; approximately 37 pairs of somites; telencephalon almost in contact with ventricle of heart; liver prominent; forelimb buds easily seen as definite protuberances; hindlimb buds not developed as much as forelimb buds; pontine flexure visible by reflected light; intestine enters the umbilicus.

Thirty-two-day embryo.—Weight, 186 mg.; C–R length, 9.8 mm.; we were unable to count number of somites, as this stage is not too translucent; liver well demarcated, now protrudes ventrally on a level with the ventricle of heart; optic cup visible, lens placode just discernible with reflected light; otocyst present; fourth branchial arch almost obliterated; forelimb buds now extend down to liver, hindlimb buds extend out laterally; vertebral arch still appears open from medulla posterior-ward; maxillary and mandibular processes well demarcated; slight depression overlying pontine flexure now evident; mesencephalon beginning to protrude as a hump; evidence of genital tubercle.

Thirty-three-day embryo.—Weight, 218.7 mg.; C–R length, 11 mm.; lens placode is well developed; other characteristics are practically identical with those of embryo of 32 days.

Thirty-four-day embryo.—Weight, 232.2 mg.; C–R length, 11.9 mm.; *C*-shaped; pigmentation visible in iris of eye; third and fourth branchial arches obliterated; limb buds longer and consist of definite proximal and distal portions with slight constriction between these portions; tip of tail almost touches head; naso-lacrimal groove definite; cerebral hemispheres evident; vertebral arch almost closed.

Thirty-five-day embryo.—Weight, 351.2 mg.; C–R length, 13.6 mm.; liver comprises approximately one-sixth of the mass of embryo; snout now more definite, mesial and lateral nasal processes well demarcated; embryo appears to be in process of straightening from the *C*-shape, as the tail is now farther away from the head.

Thirty-eight-day embryo.—Weight, 443 mg.; C–R length, 17 mm.; *C*-shaped and wrapped around liver; prominent mesencephalic hump; liver very prominent and constitutes approximately one-fifth of the total mass; auricle of ear present as small triangular flap; digits are apparent, but not well differentiated.

Forty-five-day embryo.—Weight, 2,000 mg.; C–R length, 26.9 mm.; lens of eye well formed; corneal covering appears complete; blood vessels visible in region surrounding eye; mouth open and tongue protruding slightly; auricle of ear folded over laterad; digits differentiated, both hoofs and dew claws; vibrissal follicles appear above and below eye and between rami of lower jaws and cheeks; ribs well formed and visible through skin; and phallus present.

Forty-eight-day embryo.—Weight, 2,400 mg.; C–R length, 32.4 mm.; shaped like an opened letter *C*; depression overlying pontine flexure no longer obvious externally; eyeballs protrude; mouth open and tongue protruding; snout fully formed, but blunt; auricle of ear folded laterad covering external auditory meatus; angle formed between long axis of body and a line drawn from muzzle through ear is less than 90° (ca. 45°); Meckel's diverticulum appears to extend approximately 5 mm. into umbilicus; cerebral hemispheres protruding and clearly demarcated; external sex organs still at indifferent stage, phallus approximately 2.0–2.5 mm. in length, including posterior curvature; coronal and sagittal sutures appearing.

Fetal Development

A description of seven age stages in the fetal development follows, interspersed with major changes appearing in the transition periods between these selected examples.

Forty-eight-day fetus.—Weight, 2.4 gm.; F-R length, 32.4 mm.; shaped like an opened letter *C*; mesencephalic hump obvious; liver prominent; iris pigmented; vibrissae follicles just visible above eye; mouth open and tongue protruding; digits differentiated, dew claws present; angle formed between long axis of body and a straight line drawn from the muzzle through the external auditory meatus is less than 90° (ca. 45°); cerebral hemispheres slightly prominent; rib cage well formed and visible through skin; phallus curved caudad.

In the interval up to 60 days the liver becomes less prominent, and the fetus becomes gradually extended. The mesencephalic hump recedes and

assumes adult proportions at about 57 days. Eyelids begin to develop (ca. 50 days) and completely cover the eye at approximately 57 days. Vibrissae follicles make a definite appearance above and below the eyes and between the rami of the lower jaw and the cheeks (ca. 57 days). The mouth becomes closed and the gum line becomes evident in the lower jaw (50–57 days). The vertebral arch continues to fuse to cover the spinal cord. The cerebral hemispheres become more prominent, and the sagittal suture now becomes distinct (ca. 57 days).

Sixty-one-day fetus.—Weight, 17.7 gm.; F–R length, 74.3 mm.; *C*-shaped not fully extended; liver approaching adult proportions, but still protrudes slightly; mouth closed and lower lip protrudes beyond upper lip; spinal vertebral processes visible; vibrissae follicles now visible on chest and upper forelimbs; sagittal and coronal sutures evident; four teats well formed; superficial blood vessels well developed in head, neck, chest, and forelimbs.

General changes occurring between 61 and 73 days are the continued reduction in the size of the liver, the further development of the snout to resemble the adult form, the appearance of vibrissae follicles on the abdomen and trunk (ca. 68 days), the increased expansion of the cerebral hemispheres, and the folding of the ear auricles from a lateral to a mesodorsal position (ca. 68 days).

Seventy-three-day fetus.—Weight, 49.8 gm.; F–R length, 110.7 mm.; shaped like an adult; liver still prominent, but does not form a ventral bulge; brown pigmentation present on blunt end of nose between the two nares and down to the lip; hoofs approaching adult form; first indication of metatarsal glands; phallus, in the case of a female, is very short and located posterior almost adjacent to the base of the tail.

Noticeable features between 73 days and 83 days are the appearance of antler "buds" at the lateroposterior margins of the cerebral hemispheres, the more distinct development of the metatarsal glands, and the less discernible evidence of the coronal suture (ca. 76 days).

Eighty-three-day fetus.—Weight, 111.2 gm.; F–R length, 142 mm.; angle formed between long axis of body and a straight line drawn from the muzzle through the external auditory meatus is almost equal to 90°; liver practically adult in its proportions; cerebral hemispheres prominent; coronal and sagittal sutures no longer discernible; indications of incisor and canine teeth covered by membrane; primordia of antlers distinct in the male.

Between 83 and 111 days, the fetus straightens so that the angle formed between the long axis of the body and a straight line drawn from the muzzle through the ears is greater than 90° (ca. 86 days), the liver assumes adult proportions (ca. 86 days), and the tarsal glands become apparent (ca. 89 days).

One-hundred-and-eleven-day fetus.—Weight, 545 gm.; F–R length, 232 mm.; liver not obvious externally and abdominal region is depressed in comparison with the thoracic region; eyelashes and eyebrows not present; pigmentation on nose dark brown, interspersed with white spots; tail, black tip; legs and hoofs, brownish-black; auricles of ears becoming darker; antler primordia dark color; external nares open; hair present on muzzle, between rami of lower jaws and cheeks, and on chest; skin thicker and nontransparent.

Between 111 days and 144 days, the appearance of hair is noted on the auricles of the ears, legs, abdomen, and the neck (ca. 117 days). Hair is also noted, about 137 days, on the margins of the metatarsal glands, covering the tarsal glands, and on the bordering surfaces of the external urogenital parts. The teats become well formed; the incisors and canines are well demarcated, but covered by the periodontal membrane; the cerebral hemispheres are no longer discernible and now comprise the forehead (ca. 117 days); pigmentation becomes black on the end of the nose; the head, legs, and ears acquire a darker color; two whitish parallel stripes of hair appear on the dorsal portion of the neck, and whitish fawn-spots appear on the trunk.

One-hundred-and-forty-four-day fetus.—Weight, 1,600+ gm.; F–R length, 327 mm.; teeth, well demarcated, but covered by membrane. Hair: long hairs present above and below eyes, muzzle, and on anterior portion of lower lip; eyelashes well developed; black hair on tip of tail; forehead, darker and well developed; trunk, fuzz on dorsal and lateral aspects; chest and abdomen, well developed anterior to the umbilicus; forelegs, well developed on lateral portions of upper forelegs in region of olecranon process and humerus; hoofs, short hair present just above hoofs; tarsal glands, covered with hair; metatarsal glands, well defined, grayish-white streak with a white narrow ridge extending the length of the gland, with short fuzz covering grayish-white portion of the gland. Pigmentation: nose, black between nares with two vertically parallel rows of white spots; hoofs, slight darkening on upper portions; trunk, light spots on dorsal and lateral aspects extending posteriorly to the rump, and on the sides to an imaginary line drawn from the head of the humerus to the head of the femur.

Between 144 days and 174 days, the hair covering becomes complete, thick, and distributed as in the fawn. The enamel tips of the incisors and canines become exposed through the membrane at approximately 161 days. The auricles of the ears are no longer appressed to the head.

One-hundred-and-seventy-four-day fetus.—Weight, 2,800+ gm.; F–R length, 443 mm.; hair covering complete, thick, and distributed as in newborn fawn; incisors and canines appear fully exposed; light fawn-spots on trunk very marked; chest covered with dark-brown hair; light-brown hair on abdominal region from umbilicus to anus; black hair on end of tail (approximately 25 mm.); metatarsal glands practically obscured by long bordering hair; tarsal glands completely covered by thick, light-brown hair.

The length of the gestation period was not established, and a term fawn was not available for description. A new-born fawn, the age of which was estimated to range between 7 and 10 days, was discovered in the exhibition pasture of the Bison Range on July 6, 1956. The following measurements of this fawn were recorded: F–R length, approximately 520 mm.; weight, approximately 4,309 gm. (converted from pounds); contour length, approximately 774 mm.; hindfoot length, approximately 285 mm.; length of auricle of ear, approximately 114 mm.

There were no noticeable differences in the observed fawn and the 174-day fetus except in size, and growth and darker coloration of the hair. No odor could be detected from the fawn by three observers.

DISCUSSION

Growth.—The growth curve (Fig. 1) obtained in the study is based on only five known-age specimens, but the curve possesses the characteristics of the growth curve derived for the northern white-tailed deer (Cheatum and Morton, *op. cit.*) based on 12 known-age specimens. In determining the actual age of known-age specimens, an error is probably introduced by lack of knowledge concerning the lapse in time between ovulation and fertilization during the period of estrus. The dates of breeding are considered, in this study, to be the dates of fertilization and the initiation of development of the ova. A growth-rate comparison of length (F–R) and weight (Table 2) indicates a more rapid growth in weight during the embryonic and early fetal periods. When the weight to F–R ratio is plotted against age, the relative increase in weight to length is shown to occur primarily during the early fetal period.

Breeding period.—Calculated dates of breeding revealed that 95 per cent of the breeding occurred between November 10 and December 1, inclusive, with November 20 as the average. Robinette and Gashwiler (1950) estimated the peak of mule deer breeding in Utah to occur from November 20 to December 2. Chattin (*op. cit.*) calculated that 88 per cent of 43 mule deer does in northern California and southern Oregon were bred between November 15 and December 6. Chattin also calculated that no does were bred between December 7 and 17, inclusive, while the calculations in the present study revealed that no does were bred between December 8 and 16, inclusive. In the Yosemite region in California, Dixon (1934) estimated that all of the mule deer breed during a 48-day period (December 10–January 27). The breeding in this study occurred over a 52-day period (November 5–December 26). Differences in latitude probably account for the later season in these two cases. The period of breeding of the Doyle mule deer herd (Lassen, *et al.*, 1952) in California and Nevada extended from November 18 through December 27, a 40-day period.

Recurrence of estrus.—The gap in breeding dates between December 8 and 16, coupled, about the middle of November, with the apparent signs of estrus of the penned deer, which were disturbed at that time and then were bred after December 17, seems to indicate a recurrence of estrus if successful mating does not occur during the first heat period. Chattin (*op. cit.*) noted a similar gap following the initial peak of successful breeding, and Cheatum and Morton (*op. cit.*) demonstrated, by the presence of corpora lutea, that it is possible for estrus to recur three times in the northern white-tail in New York. Histological examination of the ovaries of the December-bred does in this study have not been made at this writing.

Embryonic development.—The development of external features of the mule deer embryo appears to follow the typical mammalian pattern. The rate of development and appearance of major external landmarks is so rapid in the embryonic growth that a larger collection of known-age embryos and a histological study are necessary in order to substantiate the sequence of descriptive stages presented in this paper. The use of weight and length in determining the ages of embryos seems to the writers to be a relatively inaccurate criterion, due to (1) dif-

ferences in technique employed by the investigators and (2) variations in rate of development of embryos of the same age. Features that the writers feel would be of primary importance in differentiating embryonic stages are the following: (1) number of pairs of mesodermal somites, (2) the appearance and progress of the branchial arches, (3) the development of the limb buds, (4) shape, (5) liver development and its relative size, (6) pigmentation of iris, and (7) the appearance of the auricles of the ear.

Fetal development.—A comparison of the growth of the mule deer fetus with the northern white-tail (Armstrong, *op. cit.*) shows a greater increase in weight for the mule deer during fetal development. Between day 57 and day 174 (117-day period), the mule deer fetus gained approximately 2,788 gm. in weight, whereas the white-tail (Armstrong, *ibid.*) gained 2,388 gm. between day 60 and day 184 (147-day period), revealing a greater increase by approximately 400 gm. for the mule deer in a shorter period of time (30 days shorter). This difference is borne out in the average weight of the mule deer fawn, which is estimated to be about 3,265 gm. (Robinette and Olsen, 1944), as compared with 2,702 gm. for the white-tail fawn (Armstrong, *op. cit.*). This produces a difference in average fawn weights of approximately 563 grams. The F–R lengths of the two species appear to approximate each other rather closely, with slight differences appearing at various ages. Other comparative measurements exhibited reciprocal deviations throughout the fetal period. These deviations can likely be accounted for in minor differences existing in the techniques employed by the investigators. Shape and appearance of external characters would seem to be of more value than measurements in determining age in early fetal development.

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We are indebted to Philip L. Wright and Howard S. Sears for their permission to use collected material. A special thanks is extended to the National Bison Range personnel of the U.S. Fish and Wildlife Service, whose co-operation made possible the acquisition of materials and data used in this study. Special acknowledgment is presented to John E. Schwartz, Superintendent of the National Bison Range, for his material aid and co-operation, and also to Victor May and Clarence Young for their aid in handling and care of the deer used in this study. We also wish to thank the Montana Fish and Game Department and the Montana Cooperative Wildlife Research Unit for their aid.

SUMMARY

An examination of 180 embryos and fetuses of the Rocky Mountain mule deer was undertaken to describe the major morphological changes that occur during prenatal development. A prenatal-growth curve was established for the mule deer based on crown–rump or forehead–rump lengths and age in days of five known-age specimens. This growth curve compared favorably with curves established for the white-tailed deer, sheep, and the ox. Specimens of unknown age were aged by use of the growth curve. Growth of length of the auricles of the ears and hindfoot length appear to have a definite relation to age and might be of use to the field man. Weight to forehead–rump ratio, when plotted on age, reveals the relative increase in weight compared with F–R length during the late-embryonic and early-fetal growth periods. The calculated peak of the breeding season occurs on November 20 plus or minus 7 days. Sequential stages in this development of the embryo to age 48 days, and seven selected age stages with transitional periods in fetal development are described. The approximate time of the appearance of major external characters are included. The weight of the mule deer fetus exceeds the weight of the white-tailed deer fetus, but the F–R lengths of the two species are closely similar at comparable stages of development. Eighty-seven per cent of the does over 1 year of age collected in December and later were pregnant. The Bison Range herd had a fetus–doe ratio of 1.66 based on pregnant animals in the present collection. Embryos are estimated to

have been implanted at 27–29 days after breeding occurred.

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EXPERIMENTAL STARVATION OF PHEASANTS

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This investigation was designed to provide information on winter starvation of pheasants (*Phasianus colchicus*) under natural conditions in the north-central prairie region. Specific objectives were to determine the length of time pheasants can survive without food, to observe the symptoms of starvation in pheasants, and to study some effects of cover on survival of starving pheasants. An attempt was made to obtain information on the physiology of winter losses of pheasants and on the relationship between winter cover and the availability of food for this species.

The study was carried out jointly by Pittman-Robertson Project W-11-R and the Section of Game, Minnesota Department of Conservation. Charles E. Gates, Station Statistician, Agricultural Experiment Station, University of Minnesota, suggested the statistical procedures.

METHODS

Thirty-six wild pheasants and 20 artificially propagated birds were used. The wild pheasants were trapped in Ramsey County, Minnesota, during January 1956. Trapping was difficult due to mild weather and light snow cover; therefore, the number of birds available for each experimental group was small from the statistical point of view. As the pheasants were trapped, they were leg banded, weighed, and placed in pens supplied with food, grit, water, and shelter. It was hoped that the birds would become accustomed to the stress of caging before the start of experimental fasting. However, since the experiment was carried out under actual winter conditions, the birds did not have time to become used to captivity and

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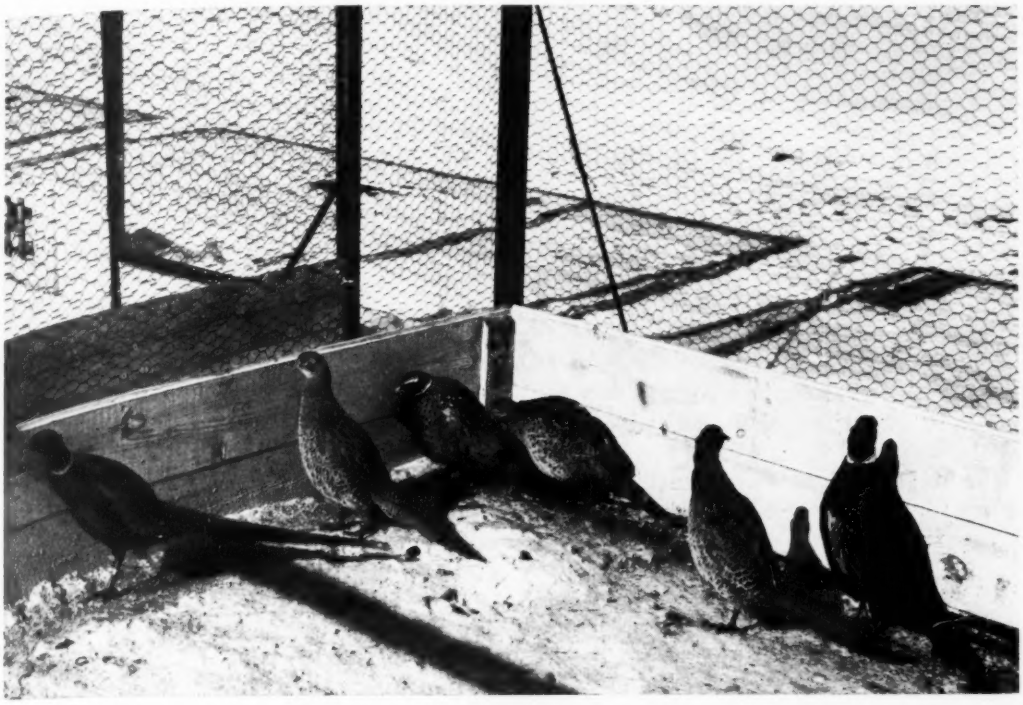

FIG. 1. Experimental pen with starving wild-trapped pheasants. These birds have been without food for 12 days. The male in the corner is in the squatting position indicative of the final stages of starvation.

artificial food. By February 2, when the experiment started, many of the wild birds had lost weight, and some were badly scalped. The wild birds were of smaller size and in poorer physical condition at the start of the experiment than the artificially propagated birds.

At the start of the experimental starvation on February 2, the wild birds were separated into four groups of 9 each, and the artificially propagated birds into two groups of 10 each. To study the effect of cover on rate of survival, part of the experiment was carried out in the shelter of a typical farm windbreak and part in an exposed area. The two sites were approximately 500 ft. apart. Control groups of 9 wild birds were used at each site. Nine wild and 10 artificially propagated birds were starved at each site.

The birds were placed in square wire pens 10 ft. on a side and 8 ft. high. There was no floor in the pens. Boards extended approximately 18 in. above the ground on all sides of the pen. These boards provided some shelter for the birds; but, since they were an integral part of the pen, they were not removed (Fig. 1).

Maximum and minimum temperatures, wind velocity, and precipitation were recorded twice each day at each site. Records of weight changes were kept for all individuals. Behavior and physical condition of the birds were observed three times daily. Dead birds were removed as soon as they were discovered. The carcasses were weighed and external characteristics, such as condition of plumage and flesh, were noted. All of the birds were taken to the Diagnosis Laboratory in the School of Veterinary Medicine, University of Minnesota, for complete examination after death.

ANALYSIS OF DATA

The experiment was designed to yield information on the following aspects of pheasant starvation:

1. Differences in effects of fasting upon wild and artificially propagated stock.

2. Differences between males and females.
3. Effect of windbreak shelter on the length of survival.
4. Appearance and behavior of starving pheasants.

Comparisons between groups of starved birds and controls were made on the basis of number of days of survival without food and on body weight lost.

Weather conditions.—Air temperatures during February varied from 40°F. to –14°F. The average maximum temperature at the exposed pens was 25.9°F.; at the sheltered pens, 24.2°F. The average minimum temperature at the exposed pens was 3.2°F.; at the sheltered pens, 4.9°F.

There were light snow flurries on February 16, 17, and 20. A light freezing drizzle began during the late evening of the 23rd and continued through the morning of the 24th. A total of 0.64 in. of precipitation was recorded for February by the U.S. Weather Bureau Station at Fairmont, 25 miles south of the experimental area.

Wind velocity was recorded at the exposed pens and at the pens sheltered by the windbreak. The average velocity at the exposed pens was 6.5 m.p.h. compared to 4.2 m.p.h. in the sheltered area. The strongest wind occurred on February 24, when the anemometer registered 20 m.p.h. near the exposed pens. Winds of 14 m.p.h. were recorded on February 5 and 25. Except on these 3 days, winds did not exceed 12 m.p.h.

Controls.—One group of 9 control birds was placed in the sheltered area, and a group of 9 was placed in the exposed area. All of the controls were trapped wild birds. Ample food was available to these throughout the experiment. None of the birds died or exhibited large weight changes. Most of the wild birds had lost weight between the date of capture and the date when they were put into the experimental pens. However, these birds apparently acclimated themselves to the pens and began eating. Small weight gains were noted in many of the control birds as the experiment progressed.

Differences between wild and artificially propagated stock.—It has been shown (Benedict, 1937; Brody, 1932; Gerstell, 1942; Gerstell and Long, 1939; Latham, 1947; and others) that the length of time birds placed under stress survive is dependent upon the condition of the birds and upon the characteristics of size, race, sex, and age, which affect the rate of metabolism.

Table 1 shows that both sexes of artificially propagated pheasants were heavier at the beginning of the experiment than the wild-trapped birds. Throughout the experiment, artificially propagated birds survived longer than wild birds (Table 2). These findings concur with those of Benedict, Horst, and Mendel (1932), Kabat, *et al.* (1956), Kendeigh (1945), and Phillips, Ashworth, and Brody (1932), indicating that, other factors being equal, the larger the animal the greater its ability to resist the stress of starvation. In most cases, the heaviest birds in each experimental group lived the longest. The largest bird in the experi-

TABLE 1.—AVERAGE WEIGHT LOSS OF PHEASANTS STARVED TO DEATH, STATE GAME FARM, MADELIA, MINNESOTA, FEBRUARY 1956

TEST GROUP	NO. OF BIRDS		WEIGHT (lb.)		PER CENT WEIGHT LOST
			Initial[1]	At Death	
Wild ♂♂	9	Mean	2.7	1.3	
		Range	2.5–2.9	1.1–1.5	52
Wild ♀♀	9	Mean	1.9	0.9	
		Range	1.6–2.2	0.8–1.0	53
Game-farm ♂♂	9	Mean	3.2	1.6	
		Range	2.6–3.7	1.2–2.1	50
Game-farm ♀♀	10	Mean	2.4	1.3	
		Range	2.1–2.7	1.1–1.6	46

[1] The initial weight of the wild birds is the average weight of the birds at the time they were caught.

TABLE 2.—SURVIVAL OF STARVING PHEASANTS AS RELATED TO WINDBREAK SHELTER, SEX, AND ORIGIN OF STOCK, STATE GAME FARM, MADELIA, MINNESOTA, FEBRUARY 1956

TEST GROUP		DAYS SURVIVAL WITHOUT FOOD[1]			
		Exposed		Sheltered	
		♂♂	♀♀	♂♂	♀♀
Wild	Mean	12	11	12	11
	Range	8–15	7–13	9–14	10–13
	No. of birds	(4)	(5)	(5)	(4)
Game-farm	Mean	16[2]	17	20	16
	Range	13–26	13–21	12–26	13–25
	No. of birds	(4)	(5)	(5)	(5)

[1] Analysis of variance revealed no significant differences between sexes or between exposed and sheltered birds. The difference between wild and artificially propagated groups was significant at the 0.01 level.

[2] The largest male (data not included in this table) was still alive after 30 days without food (see text).

ment, an artificially propagated male weighing 4.3 lb. at the start, was still alive after more than 30 days without food. Warm weather on March 1 and 2 melted the snow in the pens, and this bird was observed feeding on the newly exposed ground. Apparently the bird found enough food to maintain its body weight (2.8 lb. at this date). Since this was the only experimental bird still living, the study was concluded and the bird was placed back on feed.

Although the wild birds were not as heavy as the artificially propagated birds, they lost a higher percentage of their initial body weight before succumbing (*t* test for difference significant at 0.05 level). This may indicate that the birds of wild origin were more hardy than birds that originated at game farms.

Race or origin also affects metabolism of pheasants. Gerstell and Long (*op. cit.*) and Benedict (*op. cit.*) found that metabolic rates varied among different races of the same species. The trapped wild pheasants used in our experiment were hatched and reared in the wild by wild parents. The artificially propagated stock was produced in captivity under ideal conditions by breeding birds held in captivity for many generations. The wild birds have a strenuous existence overcoming adverse weather and predation and in finding food and shelter. In comparison, pheasants raised under artificial conditions lead quiet, sedentary lives. It may be, therefore, that the two groups of birds represent somewhat different physiological races that respond differently to the stress of starvation.

The wild birds were subject to both the stresses of starvation and of caging, whereas the artificially propagated birds were accustomed to caging. It is our opinion that the differences in weight, stress, and the possible physiological differences all contributed to the variation in length of survival.

Differences between males and females.—No significant difference in length of survival of males and females was found (Table 2). We expected the males to survive longer than the females because of their heavier weight. The fact that they did not indicates that physiological differences, which give the female a superior ability to resist these stresses, might exist between the sexes. Latham (*op. cit.*) reported that hen pheasants were definitely more resistant than males to hardships such as weather extremes and starvation. Jordan (1953) found that hen mallards survived longer than drakes in starvation experiments. He believed that this difference was partially caused by differences in rates of metabolism.

Effect of windbreak shelter.—Game managers have long recognized the need of winter cover for pheasants. Under the conditions of our experiment, the pheasants in the shelter of the windbreak survived no longer than those starved in an exposed location. We believe that the mildness of the weather during the study and the design of the experimental pens prevented an accurate comparison of sheltered and exposed sites. We

also frequently observed birds that were apparently trying to obtain shelter from the wind by huddling close to the boards that supported the sides of the pen.

Appearance and behavior of starving pheasants.—The pheasants being starved did not exhibit any change in external appearance or behavior during the first 3 days. On the fourth day, the wild birds began digging through the crusted snow in the pens in search of food. The artificially propagated birds did not start scratching for food until the sixth day.

The latter group of pheasants began feather picking (cannibalism) on the fourth day. This became increasingly severe as the stronger birds picked on the weak and dead birds. Dead birds were removed from the pens immediately upon discovery, but in several cases the surviving birds had already eaten small portions of the carcasses. No cannibalism was observed in the wild birds.

Some of the weaker birds in both groups began to appear listless and "droopy" by the sixth day. These birds moved slowly, did not hold their wings normally and were frequently observed standing in a "hunched up" position with their feathers fluffed and head and neck drawn in.

Both groups showed similar behavior patterns during the final stages of starvation. The birds moved very little and appeared to be in a coma. The eyes were closed, and the head and neck were pulled in close to the body. Feathers were fluffed, and each bird looked as if it were squatting (Fig. 1). This attitude was characteristic of all the birds for a period of at least 24 hours preceding death and should be of value in the detection of starvation in the wild.

Another character that can be used to detect starvation is the condition of droppings. Droppings of the healthy birds were of a semisolid texture and dark gray or brown in color. As starvation progressed, the droppings became more watery and lighter in color. Excreta just prior to death had the consistency and appearance of milk.

Autopsy data.—After the pheasants that died in the experiment were autopsied in the Diagnosis Laboratory, Reuel Fenstermacher and J. H. Sautter stated generally that little or no fat was present in the birds and that in many cases the musculature was wasted or atrophic.

The following report is based on tissues from representative specimens selected for histopathological examination:

"All of the tissues were examined microscopically and showed no changes which were thought due to the diets. There was an occasional focus of white cells in the liver or in the kidney which was an incidental finding. There was also an occasional deposit of calcium or something of that nature, but nothing which indicated that it was related to the starvation diet. An occasional tissue showed granular changes suggestive of cloudy swelling or some other minor change in the tissue but entirely unrelated to the problem of diet."

CONCLUSIONS

The weather during the course of the study was milder than is normal for this region. However, it was quite severe when compared to that encountered in certain phases of similar projects carried out by workers in other states (Gerstell, *op. cit.*; Latham, *op. cit.*; and others). These studies and the present study point out that ring-necked pheasants are unusually hardy birds, capable of going without food for 2 or more weeks during severe weather.

Detailed studies by Kabat, *et al.* (*op. cit.*) on stress resistance and survival of hen pheasants in Wisconsin point out many complexities of starvation. They found that seasonal variations in resistance to the applied stresses of caging and starvation were related to the physiological condition of the hen at particular seasons. The portion of their investigation most comparable to the present study was conducted in February 1951. The estimated average survival time of immature hens was 27 days. The reason for the longer survival of these birds compared to the 16 days' survival of artificially propagated hens in the sheltered pens in the present study may be that, in the Wisconsin experiments, small cages kept in an

unheated building were used, whereas our experiments were conducted in large pens exposed to the weather.

In a comparison of stress resistances between two groups of wild and artificially propagated hens, Kabat, *et al.* (*ibid.*) found that wild birds had a shorter survival time than game-farm controls. Their data indicated that ". . . both groups of wild birds had been undergoing the natural stress of a mild disease condition and/or malnutrition which decreased their ability to resist the applied stress [of caging and starvation]." They also report that by the fourteenth stress day the two groups of wild hens had lost 30 per cent and 31 per cent of their initial body weight, while the artificially propagated control groups had lost 18 per cent and 20 per cent, respectively. After 8 days, the sheltered group of wild Minnesota hens had lost 38 per cent and the artificially propagated hens 23 per cent of their initial weight. The present study showed that wild hens lost an average of 53 per cent of their initial weight before dying and that artificially propagated hens died after losing 46 per cent of their initial weight.

The information obtained in this experiment indicates that, in Minnesota, pheasants can survive in midwinter for at least 2 weeks without food of any kind. However, as Kabat, *et al.* (*ibid.*) mention, abundant high-value food during the winter may be of paramount importance to high reproductive success during the ensuing breeding season as well as to survival.

SUMMARY

Wild and artificially propagated ring-necked pheasants were starved experimentally in outdoor pens in southern Minnesota in February 1956. The average maximum temperature was about 25°F., and the average minimum, about 4°F. Most of the birds succumbed after 16 days of starvation. In every phase of the experiment, artificially propagated birds survived longer than wild birds. The wild birds did not die until they had lost a higher percentage of their initial body weight than the game-farm birds. There was no significant difference in length of survival of males and females. Pheasants starved in the shelter of a windbreak did not live longer than those starved in the exposed location. The mildness of the weather and the design of the experimental pens prevented an accurate comparison of sheltered and exposed sites. All birds exhibited characteristic behavior for a period of at least 24 hours preceding death. The excreta of starving birds provide another criteria for the detection of starvation in the wild.

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A 4-YEAR STUDY OF WOOD DUCKS ON A PENNSYLVANIA MARSH[1]

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The status of wood duck (*Aix sponsa*) populations has been the subject of investigations in several states during recent years. Major studies were conducted in Illinois (Bellrose, 1953), Massachusetts (McLaughlin and Grice, 1952), Vermont (Miller, 1952), and New Hampshire (Lee, 1953). In 1953 the Pennsylvania Cooperative Wildlife Research Unit initiated a wood duck study as part of a waterfowl-research program in northwestern Pennsylvania.

The wood duck is one of the principal nesting species of waterfowl in Pennsylvania, and it also is of major importance to the sportsman there during the hunting seasons. This study has revealed a definite decrease in the nesting population, and a subsequent decline in the productivity of the wood duck from 1953 to 1956 on one of its major breeding areas in Pennsylvania. The future of this species as a gamebird in northwestern Pennsylvania may be decided by the adoption of proper management on these breeding areas. The purpose of this paper is to discuss the possible relationships of the factors affecting the decline of this population.

Description of the Area

Conneaut Marsh, located in northwestern Pennsylvania, was chosen for this study because (a) it was known to have a nesting population of wood ducks, (b) it was a popular hunting area, and (c) it was owned by the Pennsylvania Game Commission. The marsh lies in one of the typical flat-bottomed valleys of the region that are filled with glacial outwash, and contain streams of low gradients. The marsh is 9 miles long and averages about ½ mile in width.

The nesting study was centered on the lower section of the marsh which is surrounded by woodlands and still contains many dead, standing tree trunks. After spring run-offs receded, water levels were stabilized by a large beaver dam. The vegetation here is primarily dotted smartweed (*Polygonum punctatum*) with scattered colonies of bur-reed (*Sparganium eurycarpum*), buttonbush (*Cephalanthus occidentalis*), and spatter-dock (*Nuphar advena*). Trees of the surrounding woodlands are mainly red maple (*Acer rubrum*), American elm (*Ulmus americana*), and black ash (*Fraxinus nigra*).

The wood duck was the only species of waterfowl to nest on Conneaut Marsh in significant numbers during the investigations. Approximately 400 game-farm-reared mallards (*Anas platyrhynchos*) were stocked throughout the marsh by the Pennsylvania Game Commission during each year of the study and were seen regularly.

Methods

These nesting studies were concerned with the usage of wood duck nest boxes erected by the Pennsylvania Game Commission prior to 1953. These boxes, fastened to trees or dead snags, were of two types. The first was made from a common nail keg with a board roof, and was provided with a 4-in.-diameter entrance hole. The second type was constructed from rough pine boards and was about 1 ft. square and 2 ft. high with the same size for the entrance hole.

Numbered metal tags were put on the boxes, and nesting data and other occupancy data were recorded for each box. Examination of the boxes was made at 2-week intervals during each nesting season, except in 1954, when they were checked weekly. A canoe was used when water levels were adequate, but when they were low, examina-

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tions were made with the aid of a small ladder and climbing irons.

Incubating wood ducks were banded when encountered in the nest boxes, and band numbers on previously banded birds were recorded.

NEST-BOX USAGE AND PRODUCTION

Seventy-nine boxes were available for use by wood ducks in 1953. This number was reduced to 62, 49, and 32, respectively, in the succeeding 3 years. This decrease was caused mainly by (a) collapse of the snags on which the boxes were fastened, (b) boxes becoming nonfunctional due to loss of parts, and (c) use of the boxes for fuel by fishermen.

Wood ducks began arriving on Conneaut Marsh in late March and early April. Although a few clutches were started in March, the major egg-laying periods were in April and May.

A definite decline in the usage of nest boxes by the wood ducks was found during the 4-year study (Table 1). After 1953, when 45 boxes were used, there was a continual decrease so that by 1956 only five wood ducks were found in the boxes. Likewise, the production of ducklings declined from an estimated 248 during the first year to only 24 in 1956. A summary of the data collected during the four nesting seasons is presented in Table 1.

TABLE 1.—DATA COLLECTED DURING FOUR NESTING SEASONS

	1953	1954	1955	1956
Functional boxes available	79	62	46	32*
Boxes used by wood ducks	45	26	19	5
Number of successful clutches	16	7	14	2
Percentage of clutches that were successful	35	27	74**	40
Raccoon-destroyed clutches	21	12	2	0
Number of wood ducks produced	248	83	178	24
Average size of incubated clutch	17.7	15.3	15.5	12.3
Boxes used by hooded mergansers	4	3	4	4

* Includes six new boxes.
** Raccoon-proof device on most boxes.

TABLE 2.—DATA FROM BANDED INCUBATING WOOD DUCKS

	1953	1954	1955	1956
Number of wood ducks banded	13	15	16	1
Previously banded ducks in boxes	—	2	5	1
Banded ducks reported killed	1	1	1	1

The banding of incubating ducks revealed that very few returned to nest on the area the following year (Table 2). The highest number of returns occurred in 1955 when five previously banded birds were found in the boxes. This return probably reflected the poor, early hunting conditions of the previous fall when the wood duck kill was low. Only two attempts at renesting were encountered: one following the destruction of a clutch by a raccoon (*Procyon lotor*) and the other following an unexplained abandonment. One wood duck nested in the same box during the first three years of the study, but it was not present in 1956.

Few natural cavities were believed to have been used by the ducks for nesting sites, as all the broods observed could be associated by age and size with a successful nest in a box near the locality where they were sighted.

The hooded merganser (*Lophodytes cucullatus*) also nested on Conneaut Marsh, and its clutches were found in three or four boxes each year. Although a few merganser eggs were encountered in wood duck clutches, there were ample boxes available to prevent conflict for nesting sites.

Only four recoveries were reported from the 45 banded ducks: two were shot locally and one each in Arkansas and South Carolina.

NEST DESTRUCTION

Raccoons were found to be the major cause of nest destruction on Conneaut Marsh, 46 per cent of the wood duck clutches being destroyed by this species during each of the first 2 years of the study.

These animals swam as far as 200 yards, climbed the snags supporting the boxes, and in most cases entered the boxes to eat the eggs. On several occasions, raccoons were found sleeping in the boxes after eating the clutch.

Since predation by raccoons was such a serious factor in wood duck nesting success, several means of reducing this mortality were tried during the first 2 years of the study. The placing of a metal projecting roof guard over the entrance holes and the application of a vile-smelling bone-tar oil repellent around the base of the supporting tree trunks were both unsuccessful. The two devices that proved effective were (1) metal tunnel approaches to the entrances and (2) small elliptical entrance holes.

The tunnel approaches, 4 in. in diameter and made from "Crisco" cans, were tested by raccoons that made several unsuccessful attempts at entering boxes containing eggs. Elliptical entrance holes, 3 in. high and 4 in. wide, have been recommended for keeping raccoons out of the boxes (Bellrose, *op. cit.*). In 1954, pieces of "Masonite" with elliptical holes were placed over the entrances on four boxes. Two of these boxes were used by wood ducks, and their clutches were not destroyed despite efforts by raccoons to gain entrance.

Although the tunnel and elliptical-hole-type guards both were effective in keeping raccoons out of the boxes in 1954, the latter type was used extensively on the boxes the next year. The elliptical-hole guards were chosen because they were less expensive and more easily made than the metal tunnels. The elliptical holes were cut in 6-in.-square pieces of 1/4-in. exterior plywood. The guards were then nailed on all boxes not previously equipped with such guards or tunnels.

These boxes were readily accepted by 17 wood ducks, and their clutches were not destroyed. Raccoons failed to chew through these guards on several boxes with clutches, but repeated chewings over two or more seasons may enlarge them sufficiently to allow the raccoons to gain entrance; therefore, a more durable material should be used. The extensive utilization of these guards on the boxes in 1955 more than doubled the production of ducklings over that of the previous year (Table 1). This occurred even though the nesting population was slightly below that of 1954. Two nest boxes of the nail-keg type could not be fitted with guards, and the clutches laid in them were promptly destroyed by raccoons.

The eggs in nine boxes were punctured by the sharp bill of a bird. Red-headed woodpeckers (*Melanerpes erythrocephalus*) and/or starlings (*Sturnus vulgaris*) were believed to cause this damage, for they both were common on the marsh.

SUMMER OBSERVATIONS

Observations were made of wood duck broods through the summers of 1953 and 1954 in order to study their movements and survival. Broods could be seen actively feeding during all daylight hours as they moved about in the vegetation searching for insects. The water areas were inspected almost weekly from May through August by canoe. Trees and other high vantage points provided excellent observation of other sections. Eight broods in 1953 and five broods in 1954 were observed repeatedly. Each brood remained in a relatively limited area until the ducklings began to fly. Although a few large broods of very young ducklings were seen, the broods averaged only 6.4 ducklings in 1953 and 4.3 in 1954 at the age of 2 weeks. The cause of this decline was not known, but the marsh supported a good population of snapping turtles (*Chelydra serpentina*) and northern pike (*Esox lucius*).

The young wood ducks were all flying by late August, and several broods generally combined to form small flocks during this period. These flocks were joined by others from distant areas, and by late September and early October it was not unusual to see several hundred wood ducks flying about the marsh at dusk. Although the wood duck is considered to be an early migrant in this region, large numbers were generally found on the marsh when the

TABLE 3.—ESTIMATED KILL AND NUMBER OF HUNTERS, 1953 AND 1954

	1953			1954		
	1st Day (Thur.)	2nd Day (Fri.)	3rd Day (Sat.)	1st Day (Fri.)	2nd Day (Sat.)	3rd Day (Mon.)
Estimated kill						
Wood ducks	109	25	7	13	21	2
Mallards	117	25	34	22	39	5
Others	63	14	8	33	82	10
Total	289	64	49	68	142	17
Hunters present	407	217	222	270	334	50

waterfowl seasons opened in early October. This was especially true during mild autumns when their southward flights were delayed.

WATERFOWL-HUNTING SEASONS

The 1953 and 1954 waterfowl-hunting seasons in Pennsylvania opened at noon on October 15. After the opening day, shooting hours extended from one-half hour before sunrise to sunset. The bag limit was four ducks, but only one wood duck could be legally killed.

During the first 3 days of each of these seasons, a hunter survey was conducted on Conneaut Marsh. Hunters were interviewed, cars counted, and short questionnaires were placed on the cars. Co-operation was excellent, and 56 per cent of the hunters were contacted in 1953.

A severe summer drought preceded the 1953 season, and the open water areas on the marsh were limited to the channel through the marsh and to the back waters of two beaver dams on the channel. Warm, clear weather was the rule for the early part of the season, and over 400 hunters were present for the opening day of the waterfowl season. The majority of the hunters were from the industrial centers of western Pennsylvania, most of them being within a hundred miles of the marsh.

Bag checks on the first day revealed that 37 per cent of the kill on the entire marsh consisted of wood ducks. Eighty-five per cent of the hunters on the lower wooded section had killed wood ducks, while only 45 per cent had killed mallards. The gunning pressure was heavy for the first 3 days, Thursday through Saturday, then dropped off rapidly as the marsh was shot out. The shooting picked up again in November when black ducks (*A. rubripres*) and mallards moved into the area, but the hunting pressure never again reached that of the early season.

In contrast to the mild dry fall of 1953, high winds and heavy rains from hurricane "Hazel" hit the region on the opening day of the 1954 season. Many of the hunters gave up after a short hunt, and the kill was light. Despite the unfavorable weather conditions, 40 per cent of the parties were contacted the first day. Although a large number of wood ducks were present just prior to the opening day, relatively few were shot due to the poor hunting conditions, and the remainder moved out of the region with the clearing, cooler weather the second day. Data from the hunter surveys are presented in Table 3.

In 1955 and 1956, the waterfowl seasons opened one-half hour before sunrise on October 10, and the bag limits and shooting hours were the same as during the previous 2 years. Early-season conditions were similar for both years; clear, warm weather prevailed, and marsh vegetation was still lush and very dense. Although more water was present in the marsh than in 1953, the areas of open water remained about the same, due to the dense vegetation.

No detailed hunter surveys were conducted in 1955 or 1956, but spot checks and reports from field personnel of the Pennsylvania Game Commission indicated that hunting pressures were the same, if not greater, than in 1953. The wood duck again represented an important part of the kill during these 2 years. The condition of the

marsh vegetation was responsible for an exceedingly high loss of downed ducks, and this was the cause of much concern and discussion by experienced hunters. This high crippling loss may help explain the poor rate of returns for the wood ducks banded on the area.

Bag checks revealed that the hunters' identification of ducks they had killed was very poor. Large ducks were called "mallards" and small ones "teal." Male wood ducks in full plumage were occasionally recognized, but females were seldom identified correctly.

The only refuge available to ducks on Conneaut Marsh was a 2/3-mile section of the narrow channel on the central portion. Several open ponds were also found here, but they lacked sufficient woodland or brush to be attractive to wood ducks.

DISCUSSION

The decline of the nesting population of wood ducks on Conneaut Marsh can most likely be attributed to the combination of several factors: these were (1) heavy early gunning pressure, (2) lack of suitable refuges, and (3) the behavior of the ducks themselves. The reluctance of the wood ducks to leave their favored wooded habitats made them very vulnerable to hunters. These areas gave the birds a false sense of security, while providing cover for the gunners. On being flushed, the ducks flew from one such location to the next, and in each there were a number of concealed hunters. During the first few days of shooting, the birds were continually stirred up and were constantly within gun range of many hunters.

A system of small refuges located in suitable wood duck cover is suggested to help reduce the high early-season kill of this species in areas of high hunting pressure and limited habitat. It is the author's opinion that, if placed in flooded woodland or brushy cover, such sanctuaries would not have to exceed 100 acres in order to be effective. The dense cover would provide adequate security and feed to hold the ducks.

The effectiveness of refuges in protecting a native wood duck population is evidenced at the Pymatuning State Refuge, 12 miles west of Conneaut Marsh. This refuge contains a large section of ideal wood duck cover where hunting is prohibited. The usage of nest boxes here has steadily increased during the period of decrease on Conneaut Marsh and other unprotected areas in the region (Sickles, *in litt.*, April 3, 1958).

The opening of the waterfowl-hunting seasons during the first half of October has two disadvantages in this region. First, the lush condition of the marsh vegetation accounts for a very high loss of downed ducks; and, second, many wood ducks are still present on the marsh.

With an opening date in late October, vegetation would be flattened by frost, wood ducks would have started to move south, and those birds remaining would be mixed with increasing numbers of incoming migrants. In addition, the later waterfowl season would tend to reduce the gunning pressure, as many of the "opening-day duck hunters" would then be diverted by the very popular small-game seasons which in Pennsylvania have opened in late October during recent years. Since the possibility of a later season is remote, the refuge system appears to be the most practical solution where such conditions prevail.

ACKNOWLEDGMENTS

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SUMMARY

Wood duck nesting studies were conducted on Conneaut Marsh, Crawford County, Pennsylvania, during 4 years, 1953–56. This marsh was a major wood duck breeding area in northwestern Pennsylvania. Use of nest boxes declined from 45 in 1953 to 5 in 1956. Raccoons were the major cause of nest destruction during the first 2 years. This predation was practically eliminated in 1955 by equipping the boxes with metal tunnel guards and small elliptical entrance holes. Although production was greatly increased, the nesting population continued to decline.

Early heavy gunning pressure and lack of suitable refuges were believed to be the major factors in the reduction of the wood duck nesting population. A system of small refuges in wood duck habitat is suggested, and in sections where wood ducks make up a large part of the early kill, a later opening of the hunting season is also recommended.

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AGE DETERMINATION IN MOOSE FROM SECTIONED INCISOR TEETH

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The purpose of this paper is to present some of the results of a preliminary study in which we aged moose (*Alces alces*) by use of growth layers in the cement of incisor teeth. The techniques used in the study will also be discussed.

We wish to acknowledge the assistance of Arthur W. Mansfield of the Fisheries Research Board of Canada, who criticized the manuscript and aided in the preparation of the figures.

Laws (1952, 1953) developed a method of age determination in seals by preparing thin sections of the canine teeth and examining the regular sequence of growth layers in the dentine. This method has now been applied to a number of species of pinnipeds (e.g. Fisher, 1954; McLaren, 1958) and also odontocete whales (e.g. Nishiwaki, Hibiya, and Ohsumi, 1958). Some species, such as the fur seal (*Callorhinus ursinus*), show external ridges over the root of the canine tooth. Scheffer (1950), using marked fur seals of known age, showed that these ridges were laid down annually. The ridges correspond with growth layers in the dentine but are not so useful for aging, since they become obscured within a few years by deposition of overlying cement. The cement of marine mammal teeth also shows growth layers, but more commonly than not, deposition is very slight. Where the cement is thick, layers can be counted and then provide a check on counts of dentine layers.

Not all pinnipeds and odontocetes show regular growth layers in the teeth. It seems likely that the alternation of different types of deposition is related primarily to the

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feeding cycle, but endocrine rhythms possibly play a part. Due to lack of known-age animals, the annual sequence of growth layers has generally been determined by examination of specimens taken at different times of the year.

Laws (1953) briefly noted the occurrence of external growth ridges on the teeth of a variety of land mammals and of fossil reptiles. For this reason, we took the opportunity to explore the cement layers as age indicators in moose teeth that Pimlott had collected in Newfoundland. Sergeant's preliminary examination of a few incisors showed that growth layers could be seen in the cement, with less marked periodic growth in the dentine. A larger sample was accordingly prepared and examined. The material came from 64 moose taken in Newfoundland between 1950 and 1956, the majority in the December hunting season, but some at other times of the year. Pimlott had previously aged all these animals, using the method developed by Passmore, Peterson, and Cringan (1955), which is based largely on the extent of wear of the mandibular teeth. Yearlings can be accurately aged by this method, not only because the teeth are very little worn, but also because some teeth are incompletely erupted. Older animals are aged from mandibular tooth wear alone. We might expect this method to be reliable for the younger age classes but less reliable with increasing age, owing to variations in rate of wear.

TECHNIQUES

Since the first incisor is the largest of the four incisiform teeth and erupts first, it was chosen for age determination. In large-scale removal of incisors, the anterior portion of the mandible was removed and cooked in either a pressure cooker or an autoclave for approximately 45 minutes at 15-lb. pressure. When the autoclave was used, it was found necessary to immerse the mandibles in a water bath to prevent the cement of young teeth from cracking and peeling. Teeth were bisected longitudinally, using either a jeweler's circular saw blade or a band saw. The saw blade (obtained from the Thurston Manufacturing Co., 45 Borden Street, Providence, Rhode Island) was mounted on a grinding head and had a 3-in. diameter, 0.20-in. thickness, and ½-in. central hole, with 24 teeth to the inch; but a larger blade might well be used. The band saw was equipped with a 24-tooth, ½-in. metal cutting blade.

We found that the blades lasted much longer if the crown of the tooth, which has an exceedingly hard enamel, was not sectioned. The cut, therefore, started at the root and ran forward to the base of the crown, which was then removed with a transverse cut. To protect the operator's fingers from injury, each tooth may be held in a pair of pincers or jammed in a wooden block while being cut. To prepare sections, the cut half-tooth may be cemented with plastic wood to a wooden block, suitably shaped to receive it. A thick section is then cut on the circular saw as before. This section is ground to translucency on a fine carborundum or aluminum oxide stone. In this study, the rather elaborate grinding machine described by Fisher and Mackenzie (1954) was used, consisting of two vertically mounted grindstones, one fixed and one rotating, driven by a motor and cooled with water. Such a machine is of great value when a large number of tooth sections are to be prepared, although grinding by hand is not too laborious for a few sections.

The polished faces of half-teeth were moistened with alcohol and examined at magnifications of 10× to 40×, using a Zeiss binocular microscope. A calibrated micrometer scale was attached to one eyepiece to measure thickness of the growth layers. Under reflected light, opaque material appears white, while translucent material absorbs light and appears dark. Thin sections were mounted in alcohol and examined under the low power of the compound microscope, with condenser removed to allow light scattering. With transmitted light, opaque material appears dark and translucent material light. To avoid confusion, the terms opaque and translucent are used in our paper to describe the contrasting optical properties of the tooth tissue.

In measuring the thickness of the cement layers, care must be taken that the section lies close to the median longitudinal plane of the tooth, since, with an oblique or tangential section, a greater thickness is obtained. It may also be noted that the thickness of the cement is greater on the posterior, concave face of the incisor than on the anterior, convex face. Our measurements refer to the concave face.

RESULTS

The first permanent lower incisors of Newfoundland moose normally erupt in December or January, when the calf is 7 or 8 months old. Presumably these teeth have begun growth and are beginning to calcify about the time of birth.

Fig. 1 shows whole views of first incisors of a young and an old animal. The root of the incisor of the young animal is tapered, but in the old animal it is thickened and rugose. Fig. 2 shows longitudinal halves of sectioned incisors with the crowns removed. It can be seen that cement deposition takes place over the whole root, thinning out toward the cemento-enamel junction and the base of the root, and is thickest about two-thirds of the way toward the base. In the oldest animals, cement deposition becomes irregular, producing the rugose bosses seen in whole view. Only the localized thickenings of the cement show the full sequence

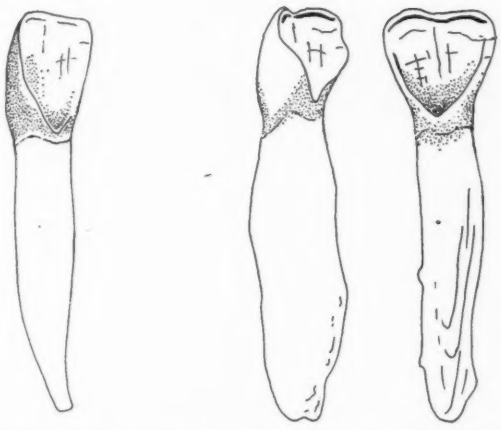

FIG. 1. Drawings of first incisors of a 1-year-old (left) and a 13-year-old moose (right) to show the general form, the cemento-enamel junction separating crown and root, and the increase in thickness of the cement that takes place with advancing age. Magnification 1.1×.

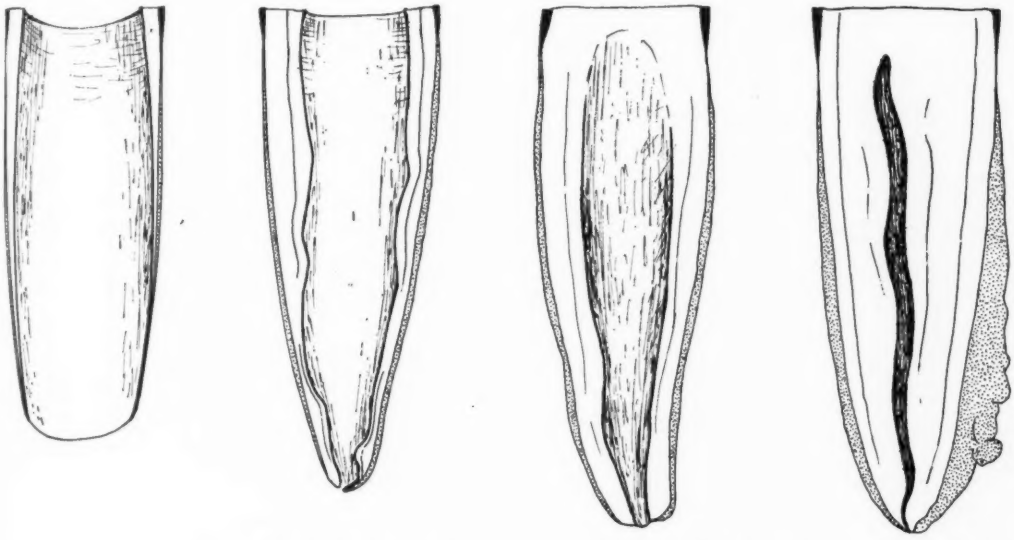

FIG. 2. Drawings of longitudinal halves of sectioned moose incisors, with the crowns removed. From left to right: a calf aged 6 months, a 1-year-old, a 3-year-old, and a 15-year-old animal. The series illustrates the increase in thickness of the dentine and consequent narrowing of the pulp cavity that occurs with age, and the form of the cement layer, which slowly increases in thickness. White—dentine; stippled—cement; black—enamel. Magnification 2.3×.

of growth layers. This explains why longitudinal, rather than transverse, sections were used in studying the sequence of growth layers.

The dentine grows inward throughout life and gradually obliterates the pulp cavity (Fig. 2). However, a small pulp cavity remains in all except some of the oldest animals, indicating that dentine deposition continues almost throughout life. In sectioned teeth, dentinal growth layers were detectable from the alternation of opaque and lighter colored zones. However, the boundaries of dentinal growth layers were indistinct and counts of their number tended to be subjective. For this reason, only cement layers were used as a guide to age in this study. Dentine layers would probably repay further study, using better methods of differentiation such as polarized light and staining with haematoxylin.

Growth layers in the cement (Fig. 3) consist of alternating opaque and translucent zones spaced at fairly regular intervals. The opaque zone is generally the wider of the two. In thin section, it can be seen that the layering is caused by a periodic concentration of cementoblasts. In macerated teeth, the empty cell bodies of the cementoblasts are filled with air, and when the section is wetted the mass of air cells refracts the light. The opaque zone is thus the zone of great cementoblast frequency.

The earliest growth of the cement, next to its junction with the dentine, was measured in the first incisor of 3 calves about 6 months old and taken in December, i.e., at about the time of eruption of these teeth. The thickness of cement was about 0.12 mm. Apparently a single opaque zone had been laid down against the border of the dentine, followed by a thin translucent zone, but the sequence is difficult to pick out in these very small, hard-to-section teeth.

The tooth of a 1-year-old taken in late May showed little change in diameter or

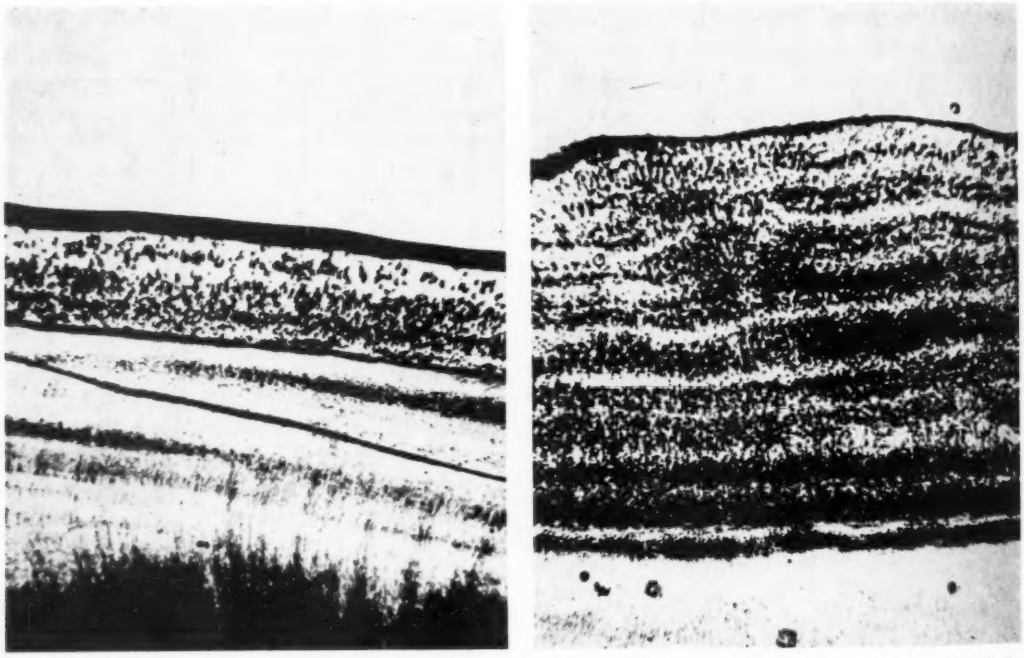

FIG. 3. Thin longitudinal sections of two moose incisors to show the structure and layering of the cement. Low-power photomicrographs without condenser and using a green filter. At left, a class III animal aged at 4 years. The sequence ends with a translucent zone in this December-killed animal. At right, a class VI animal aged at 15±2 years. Older layers gradually decrease in thickness.

structure of cement. The teeth of 9 yearlings (18 months old) taken in December showed cement with a thickness of 0.20–0.32 mm. Two complete growth layers had been formed, the sequence beginning with an opaque zone and ending with the second translucent zone. It seems reasonable to suppose that the second opaque and translucent zones are formed between the first and second winters, in which case the first translucent zone must be laid down in the first summer or fall and the first opaque zone probably about the time of birth. The whole of the first layer has a speckled appearance not seen in later layers, which seems to indicate a different type of calcification. Moreover, its diameter (0.12 mm.) is less than that of succeeding layers (0.2 mm.). These two considerations suggest that the first layer is indeed laid down before the incisor erupts in the first winter of life.

The early growth layers from age 1 to about 10 years have a fairly constant thickness, giving a linear curve of increase in thickness with time (Fig. 4). Measurement of the maximal thickness of cement can thus help to check the age of those young animals

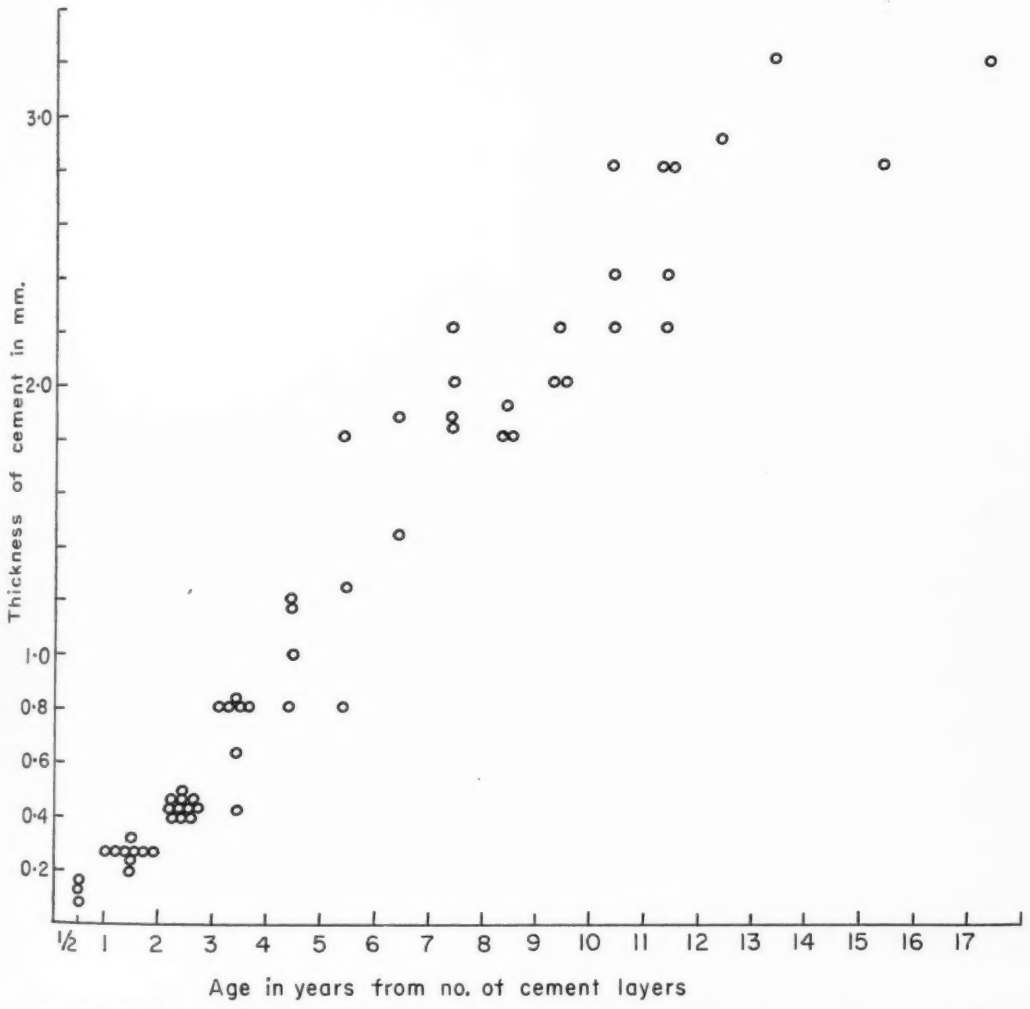

FIG. 4. Graph showing increase in maximal thickness of the cement with increasing age in the moose. The annual deposition is approximately constant from age 1 to about 8, at a rate of 0.2 mm. per annum.

TABLE 1. COMPARISON OF AGES DETERMINED FROM MANDIBULAR TOOTH WEAR AND FROM NUMBER OF CEMENT LAYERS IN MOOSE

Tooth Wear			Cement Layers														
			No. Falling in Each Age (by Years)														
Age Class[1]	No. in Sample	Est. Age (Years)	1	2	3	4	5	6	7	8	9	10	11	12	13	15	17	Known Range of Age Class in Years
I	11	1	11															1
II	15	2		12	3													2–3
III	8	3			6	2												3–4
IV	8	4				4	2	1	1									4–7
V	7	5–6						1	3	1	1	1						6–10
VI	9	6–8								1	3	2	2			1		8–15
VII	6	8–10										1	2	1	1		1	10–17

[1] Based on technique described by Passmore, Peterson and Cringan (1955).

in which the exact number of growth layers is in doubt.

The greatest age that we found in our sample of moose teeth was 17 years. At this age, the cement is of a very uneven thickness, with irregular bosses containing amorphous spherical inclusions. These inclusions obscure the growth layers in the bosses, but by looking at the margins of the bosses where the cement is not so thick, one can count the entire sequence of growth layers. Farther away from the bosses, the number of growth layers is incomplete.

DISCUSSION

Our estimates of age for classes I and II (Passmore, *et al., op. cit.*) differed only slightly from estimates based on wear, but divergence increases for older animals (Table 1). In the last 3 tooth-wear classes (V, VI, and VII), the newly determined ages of only 3 out of 22 animals fell within the previously estimated range for the class. We did not sample any animals in classes VIII or IX, which were very rare in the Newfoundland collection. Our results might have been different if we had sampled the Ontario moose which Passmore, *et al.* (*ibid.*) used in their original study. Pimlott found some fundamental differences in the tooth erosion of Newfoundland moose, as compared with Ontario moose. For example, the posterior buccal crest of the second lower molar M_2 in Newfoundland yearlings was consistently higher, narrower, and less eroded than in Ontario yearlings collected at approximately the same time of year. In spite of these differences, the variation in ages determined from tooth wear and from cement layers is so great that doubt is thrown on the ranges of the upper age classes of Passmore, *et al.* (*ibid.*).

After our data were worked up, the first incisor of a moose of known age was made available to us by R. Y. Edwards of the Department of Recreation and Conservation, Victoria, British Columbia. This animal had been tagged as a calf in May 1954 and was shot in October 1957, thus being 3½ years old at death. In section, the cement showed 3½ growth layers, the sequence beginning with a wide, opaque zone and ending with an opaque zone (Fig. 5). This validates our age scale and agrees with

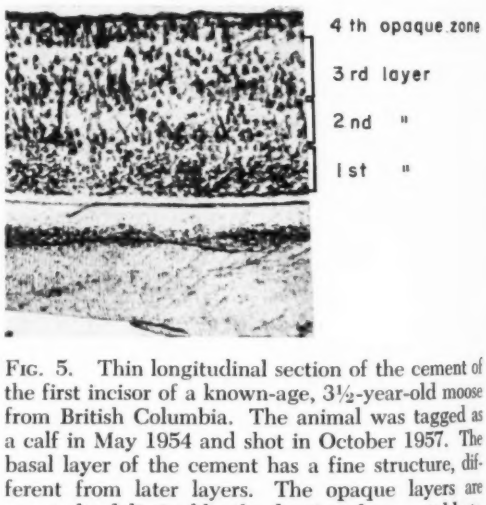

FIG. 5. Thin longitudinal section of the cement of the first incisor of a known-age, 3½-year-old moose from British Columbia. The animal was tagged as a calf in May 1954 and shot in October 1957. The basal layer of the cement has a fine structure, different from later layers. The opaque layers are seen to be delimited by the density of cementoblasts. The series ends with an opaque layer.

our suggested seasonal sequence of deposition (*see* below). However, until more known-age specimens become available to allow a further check on the accuracy of the method, we believe it wise to consider the range of accuracy to be plus or minus 1 year for younger animals, and 2 years for older animals. This caution is suggested for two reasons: first, because the first layer varies considerably in appearance and thickness (probably depending on the time of eruption of the tooth); and second, because in older animals the later growth layers are too small for accurate counting.

So few animals were taken at other times of the year than December that the seasonal sequence cannot yet be evaluated clearly. The tooth of the known-age animal, however, showed opaque cement in process of deposition in October, apparently nearly complete (Fig. 5). December-killed animals showed early deposition of translucent cement in progress (Fig. 3). Assuming that cement deposition occurs throughout the year, therefore, it seems likely that opaque material is laid down in summer and fall, translucent cement in winter and spring. It is tempting to relate this sequence to seasonal variations in feeding conditions, but more material is needed to confirm the sequence suggested.

Incisors from two Newfoundland caribou (*Rangifer caribou*), sent to us by A. T. Bergerud of the Newfoundland Department of Mines and Resources, showed exactly the same structure as the moose incisors, and provisional ages were assigned from cemental growth layers. However, the much smaller size of the teeth required the use of higher magnification to distinguish the layers, and the cementoblasts were so large in proportion to the layers that they tended to obscure them.

SUMMARY

Incisor teeth from 64 moose taken in Newfoundland were aged, using a method previously developed for marine mammals. The root of the tooth was sectioned and the structure of dentine and cement examined. The cement showed regular alternations of opaque and translucent growth zones. The zones were formed by periodic concentrations of the cell bodies of the cementoblasts. A full annual layer was found to consist of one opaque and one translucent zone. This conclusion was confirmed by examination of an incisor from a known-age (3½-year) moose, which showed 3½ layers of cement. The seasonal sequence of cement deposition was not elucidated from the limited material, but it seems probable that opaque cement is laid down in summer and fall, translucent cement in winter and spring. Ages determined for younger animals agreed with ages determined independently by the method of mandibular tooth wear, but ages of older animals were consistently higher using the new method. Incisors of caribou showed the same structure as those of the moose, but since the teeth were smaller, the growth layers in the cement were difficult to read.

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VITAMIN A AND OHIO BOBWHITE QUAIL DURING THE WINTER OF 1947–48[1]

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Since the appearance of Nestler's (1946) comprehensive study on the vitamin A requirements of pen-raised bobwhite quail (*Colinus virginianus*), attempts have been made to discover whether or not population fluctuations in wild bobwhite quail are the result of avitaminosis A (Schultz, 1948a; Nestler, *et al.*, 1949; Jones, 1950; Thompson and Baumann, 1950; Lehmann, 1953). Schultz (*op. cit.*) concluded that a vitamin A deficiency did not appear to be a limiting factor in Ohio during the relatively mild winter of 1946–47. None of 445 wild bobwhite quail collected in Iowa, Wisconsin, and Illinois during the late fall and nonsevere winter of 1947–48 showed internal symptoms of avitaminosis A (Nestler, *et al.*, *op. cit.*). On the basis of 63 wild quail collected in Oklahoma during December 1949, Jones (*op. cit.*) reported that "No cases of true vitamin A deficiency were discovered. . . ."

Thompson and Baumann (*op. cit.*) determined the vitamin A reserves of 38 wild Wisconsin bobwhite quail collected during 1946–47, 3 of which were collected in January and February. They concluded that there was no vitamin A deficiency in these individuals and that the populations sampled were not seriously affected by a vitamin A deficiency. In an extensive Texas study during the period from September 1949 to August 1951, inclusive, Lehmann (*op. cit.*) studied 270 quail specimens. This study is of special significance as it occurred during an unusually cold winter preceded by "normal times" and followed by a "dry summer." Although the winter period was characterized by "heavy" mortality and low vitamin A reserves, Lehmann only concluded ". . . that what might be termed 'simple starvation' was a potentially important factor in February–March die-off." He was noncommittal on the survival role of the low vitamin A reserves during this period.

During the winter of 1946–47 in Ohio, I collected a total of 114 specimens from two distinct quail ranges in Ohio (Schultz, *op. cit.*) in order to determine, if possible, (a) the role of vitamin A in the survival of Ohio bobwhites during the winter of 1946–47, and (b) whether or not periodic fluctuations in quail populations may result from a vitamin A deficiency during severe winter weather, as suggested by Nestler (*op. cit.*). Unfortunately, the winter of 1946–47 was relatively mild; therefore, 67 additional wild quail were collected during the following winter. This paper presents an analysis of these 1947–48 data and a comparison with the data collected in 1946–47.

This study is primarily a comparison of populations in two counties during two winters.

Methods

Sampling.—Quail were collected from the two major physiographic regions in Ohio. The state of Ohio can be divided into two major physiographic regions, based on the presence or absence of glaciation. The glaciated portion of Ohio is a region of flat to undulating terrain, of generally intensive farming and with relatively low quail populations, particularly in the western portion of the state. The unglaciated portion is a region of forested hills, consisting of small

[1] The data were collected by the writer while a research fellow of the Ohio Cooperative Wildlife Research Unit: The Ohio State University, Ohio Division of Wildlife, U.S. Fish and Wildlife Service, and Wildlife Management Institute co-operating. The assistance of J. B. DeWitt, D. L. Leedy, K. A. Mitchell, R. B. Nestler, and R. B. Will is gratefully acknowledged.

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TABLE 1.—AVERAGE WEIGHT (IN GM.) OF BOBWHITE QUAIL AND PRELIMINARY ANALYSIS OF VARIANCE[1]

MONTH AND SEX	FRANKLIN COUNTY		VINTON COUNTY	
	1946–47	1947–48	1946–47	1947–48
November				
Male	210 (1)	— (0)	199±0 (4)	199±0 (3)
Female	169 (1)	— (0)	179±5 (3)	192±8 (7)
December				
Male	197±4 (3)	— (0)	185±4 (6)	199±3 (21)
Female	198±6 (2)	— (0)	186±4 (11)	200±4 (19)
January				
Male	— (0)	192±5 (3)	208±8 (5)	— (0)
Female	— (0)	198±5 (10)	— (0)	— (0)
February				
Male	203±6 (8)	179±6 (6)	177±4 (2)	— (0)
Female	192±6 (4)	182±8 (8)	167±6 (6)	— (0)

	Degrees of Freedom	Mean Square	*F*
Among cells	18	707.91	2.75**
Within cells	112	257.15	
Total	130		

[1] Sample size in parentheses; mean ± one standard error of the mean.
**Statistically significant at the 1 per cent level.

farms, and with relatively high quail populations. This area comprises the extreme eastern and southeastern portions of the state. Quail were collected from a limited number of counties in each of these regions during the 2-year study period. During the winter of 1947–48, birds were only collected in Vinton and Franklin counties, which lie in unglaciated and glaciated Ohio, respectively; therefore, this paper involves a comparison of birds from these two counties with birds collected in the same counties in 1946–47 (Tables 1, 2, and 3). There are slight differences in sample allocation between these three tables, as it was impossible in all cases to obtain complete data, e.g., as a result of shooting, a portion of the liver might have been destroyed, making it impossible to determine total liver storage. All birds from Vinton County were collected by shooting, and most of those in Franklin County, by trapping. It is unlikely that the bait had an effect on the vitamin A reserves, as the birds were collected within less than a 24-hour period after baiting. The trapping procedure was to locate tracks after a new snowfall and to set the trap before dark. In most cases the birds were captured early the next morning.

The liver weight of birds from both counties and the body weight of birds from Franklin County were obtained with a platform gram balance, while the body weight (expressed in ounces) of Vinton County birds was obtained on an egg scale.

Analytical.—Promptly after collection, either the livers (considered to be the principal storage organ of vitamin A) were removed from the birds and frozen, or the birds were frozen intact until the livers could be removed. The subsequent storage prior to analysis was discussed in the initial paper (Schultz, *op. cit.*). The quantitative method of analysis for vitamin A used in this study was the identical method (*Schultz, op. cit.*, 1948b) applied in vitamin A research at the Patuxent Research Refuge (U.S. Fish and Wildlife Service, Department of the Interior, Laurel, Maryland) where I conducted my analyses.

Statistical.—As a result of the nonorthogonality (disproportionate subclass numbers) of the data, it was necessary to compare individually each mean classified by sex, month, year, and county. Such a procedure is the only logical one when extreme disproportionality exists and trends are expected in the population. The comparison

TABLE 2.—AVERAGE NUMBER AND PRELIMINARY ANALYSIS OF VARIANCE OF INTERNATIONAL UNITS OF VITAMIN A PER GRAM OF BOBWHITE QUAIL LIVER[1]

MONTH AND SEX	FRANKLIN COUNTY		VINTON COUNTY	
	1946–47	1947–48	1946–47	1947–48
November				
Male	843 (1)	— (0)	795± 76 (4)	219± 26 (3)
Female	684±4 (2)	— (0)	885± 80 (3)	613±193 (7)
December				
Male	482±207 (3)	— (0)	1,017±338 (6)	382± 39 (21)
Female	297± 27 (2)	— (0)	799± 65 (10)	358± 55 (19)
January				
Male	— (0)	1,932±959 (3)	724± 98 (5)	— (0)
Female	— (0)	548±231 (10)	— (0)	— (0)
February				
Male	359± 59 (6)	341± 60 (6)	1,411 (1)	— (0)
Female	875±184 (4)	267± 80 (8)	1,741±311 (6)	— (0)

	Degrees of Freedom	Mean Square $\times 10^{-5}$	F
Among cells	18	11.00	5.42**
Within cells	109	2.03	
Total	127		

[1] Sample size in parentheses; mean ± one standard error of the mean.
**Statistically significant at the 1 per cent level.

of sexes, counties, or years without considering sampling allocation in time or space is an incorrect procedure when trends or differences are expected in the variate, i.e., in the variates body weight and vitamin A reserves.

Subcategories will be called "cells" in this paper. For example, the subcategory in Table 1, distinguished by male bobwhites captured in Franklin County in December 1946, would be the cell containing the average 197.

A preliminary analysis of variance was first conducted (Tables 1, 2, and 3), and the within-cell mean square used in a multiple-range test proposed by Kramer (1956) for comparing means with unequal numbers of replications. Cells containing only one observation were not considered when applying the test, and a significance level of 1 per cent was used. I assumed that the residual errors were normally and independently distributed around zero with constant variance.

CLIMATIC CONDITIONS

Meteorological data from the Columbus weather station in Franklin County and the Jackson station, which is about 14 miles south of the center of Vinton County, were utilized. At both stations, the winter of 1946–47 was milder than that of 1947–48; however, February 1947 was more severe than February 1948, resulting from a cold snap the first few days of the month followed by unseasonably mild weather for the rest of the month. Both winters in the vicinity of Jackson were milder than in the vicinity of Columbus. With the exception of February 1948, precipitation during the winter of 1946–47 was higher than during 1947–48. The higher precipitation in February 1948 resulted from a heavy snowfall during the early portion of the month, when 12 inches of snow was reported for southern and 8 inches for central Ohio. With one exception, November 1946, the precipitation was greater in Jackson than in Columbus during all months of study.

The winter of 1946–47 was, in general, warmer than average, while that of 1947–48 was, in general, slightly colder than average. Even though the winter of 1947–48 was colder than average, snowfall was generally light, and it was not a "quail-killing winter," as in 1935–36 and 1944–45.

RESULTS AND DISCUSSION

Body weight.—As evidenced by average body weight (Table 1), I conclude that at no time during the study period were quail in *poor* physical condition. The individual body weights ranged from 153 to 223 gm. in Franklin County and 145 to 227 gm. in Vinton County. As determined by the preliminary analysis of variance, there was a significant difference among the cell means (Table 1). On the basis of the multiple-range test, there were no significant differences between average body weight in the following ranges, inclusive; 167–192, 179–199, 179–200, 185–203, and 192–208. As a result of the small sample, the cell averages 200, 203 and 208 were not significantly different from that of 177, which was based on two observations. I conclude that there was no indication of a trend in body weight through the winter months in the two counties in either year. As a result of climatic conditions favorable to quail survival and the maintenance of body weight, these results are to be expected.

There was no significant difference in the average weight of the sexes during any month in either county or winter.

A between-county comparison of cell averages of the same month, sex, and year resulted in no significant difference between counties. It should be realized that, as a result of the sample allocation, no between-county comparisons could be made for the winter of 1947–48. Similarly, between-year comparisons within a county were restricted to February in Franklin County and November and December in Vinton County. Only for males collected in February in Franklin County was there a significant difference between the cell averages for years.

In conclusion, it appears that there was no practical difference in the average body weight of bobwhite quail where monthly comparisons could be made between sexes, counties, and years.

International Units (I. U.) of vitamin A per gram of liver.—As previously stated (Schultz, 1948a), "A study based on the I. U. of vitamin A per gram of liver weight rather than on total vitamin A storage may be misleading when comparing storage in individuals. . . . In fact, it is doubted by the writer whether a practical standard can be established on a per-gram basis or per liver alone due to variability of liver weight, body weight, and other factors." Jones (*op. cit.*) agreed with these conclusions. It appears to me that there is a need for a comprehensive evaluation of data on the vitamin A reserves of pen-raised quail as related to survival. Such an evaluation should involve a multivariate analysis of the data collected with a suitable experimental design.

Since the literature reports vitamin A reserves on a per-gram and total-liver basis and there is no other established standard for the determination of vitamin A deficiency on the basis of vitamin A reserves, the data collected in Ohio are presented in these units (Tables 2 and 3).

On the basis of I. U. of vitamin A per gram of liver, there was a significant difference among the cell averages (Table 2). The individual vitamin A reserves ranged from 42 to 3,668 I. U. per gram of liver in Franklin County and 72 to 2,613 I. U. per gram of liver in Vinton County. In general, there was wide variation in individual storage within a cell. None of the birds showed external signs of vitamin A deficiency. Only 3 birds in Franklin County and 3 in Vinton County had a reserve of less than 100 I. U. of vitamin A per gram of liver. On the basis of the multiple-range test, there was no significant difference among average vitamin A storages per gram of liver in the following ranges, inclusive: 219–885, 359–1,017, and 1,741–1,932. I conclude that there is no indication of a trend in vitamin A storage per gram of liver through the winter months in the two counties in either year. Only in Franklin County in January 1948 was there a significant difference in vitamin reserves between sexes. A between-county comparison of cell averages of the same month, sex, and year resulted in a significant difference only between the average reserves of female birds collected in February 1947. As previously stated, between-county comparisons could not be made for the winter of 1947–48 and between-year comparisons

TABLE 3.—AVERAGE NUMBER AND PRELIMINARY ANALYSIS OF VARIANCE OF INTERNATIONAL UNITS OF VITAMIN A PER BOBWHITE QUAIL LIVER[1]

MONTH AND SEX	FRANKLIN COUNTY		VINTON COUNTY	
	1946–47	1947–48	1946–47	1947–48
November				
Male	3,962 (1)	— (0)	1,939±119 (4)	548± 77 (3)
Female	2,315 (1)	— (0)	2,242±208 (3)	1,720±454 (7)
December				
Male	2,030±912 (3)	— (0)	2,261±466 (6)	1,204±135 (21)
Female	1,542±138 (2)	— (0)	1,789±197 (9)	994±147 (19)
January				
Male	— (0)	5,497±2,746 (3)	1,467±203 (5)	— (0)
Female	— (0)	1,716± 697 (10)	— (0)	— (0)
February				
Male	1,423±226 (6)	1,078± 150 (6)	2,540 (1)	— (0)
Female	3,172±526 (4)	1,142± 528 (8)	3,638±563 (6)	— (0)

	Degrees of Freedom	Mean Square $\times 10^{-5}$	F
Among cells	17	60.05	4.04**
Within cells	107	14.85	
Total	124		

[1] Sample size in parentheses; mean ± one standard error of the mean.
**Statistically significant at the 1 per cent level.

within a county were restricted to February in Franklin County and November and December in Vinton County. The only significant difference within a county between years occurred in the average vitamin A reserves for males collected during December in Vinton County.

I conclude that, on the basis of the number of I. U. of vitamin A per gram of liver, in general, there was no significant difference in the average vitamin A reserves between the sexes, counties, and years. There was no significant downward trend in vitamin A reserves during the period of study in either county.

I. U. of vitamin A per liver.—On the basis of I. U. of vitamin A per liver, there was a significant difference among the cell averages (Table 3). The individual vitamin A reserves ranged from 130 to 7,920 I. U. per liver in Franklin County and 168 to 4,824 I. U. per liver in Vinton County. There was a large variation among individuals within a cell. Kramer's procedure showed no significant difference in the average total storage in the following ranges, inclusive: 548–2,261, 1,423–3,172, 1,542–3,638, and 3,172–5,497. There was no indication of a trend in total vitamin A reserves either in the sexes or counties during the two study periods. Only in Franklin County during January 1948 and February 1947 was there a significant difference between total vitamin A storage of the sexes. A between-county comparison disclosed no significant differences between the possible comparisons. Of the possible comparisons, the only significant difference within a county between years was for February females from Franklin County.

On the basis of average total vitamin A reserves, there was no indication of vitamin A deficiency during the two study periods or that a trend in total vitamin A storage existed in the sexes or counties during the two winters.

SUMMARY

The vitamin A reserves of 128 wild bobwhite quail collected from two Ohio counties during the mild winters of 1946–47 and 1947–48 were determined. There was no indication that individuals of the populations sampled were suffering from avitaminosis A. As a result of nonorthogonal data (disproportionate subclass numbers), com-

parisons between sexes and years within counties and between counties on a monthly basis were made.

In general, where comparisons could be made, there were no significant differences between sexes, years, or counties in vitamin A storage or body weight. Such a result does not imply a conclusion of no difference between the means of these categories in the population but merely that there were insufficient data to detect a real difference of the magnitude observed.

The extreme variability in vitamin A reserves of birds within a subcategory emphasizes the need for information on the relationship of vitamin A requirements to various physical and biological factors before critical levels of vitamin A reserves can be established.

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THE WILDLIFE SOCIETY

REPORT OF THE EXECUTIVE SECRETARY FOR THE YEAR 1958–59

Membership

Again this year the Society has shown substantial growth. The combined member-subscriber total for 1958 was 3,325, an increase of 121 over the previous year (Table 1). An aggressive, hard-working Membership Committee, under the chairmanship of Lee Yeager, is largely responsible for those additions of new members. Over the past 6 years the subscriber-member increase has been just under 1,000 —almost 50 per cent.

During 1958, 388 new (regular) members were enrolled. This figure is almost identical to that of the year before, when 389 were added. These substantial additions of new members, both in 1957 and 1958, are offset in part by losses of old members. However, the net gain for regular members this year was 101 and for life members 14. Even though 35 failed to renew, the number of subscribers to THE JOURNAL increased slightly from 501 last year to 507 in 1958.

The present rate of recruitment is running well ahead of that of last year. New members for 1959 total 228 compared with 186 over a corresponding period in the previous year.

The death of the following members is reported with regret: P. F. English, Michael Grzimek, T. G. Heaton, Richard B. Miller, Glenn E. Mitchell, Earl C. O'Roke, Homer L. Shantz, and W. Kenneth Thompson.

Biologists are a mobile lot, as was indicated by 905 address changes processed during the year.

TABLE 1.—WILDLIFE SOCIETY MEMBERSHIP, 1952–58

Class of Membership	ENROLLMENTS AT THE END OF THE CALENDAR YEAR						
	1952	1953	1954	1955	1956	1957	1958
Honorary	11	13	15	17	18	18	18
Life	10	10	17	27	31	66	80
Regular	1,919	2,140	2,346	2,503	2,485	2,619	2,720
Subscribers	388	377	406	429	441	501	507
Totals	2,328	2,540	2,784	2,976	2,975	3,204	3,325

Regular members accounted for 768 of the changes and subscribers for 137. Other mail, including requests for information, election returns, dues payments, etc., raised the incoming total to approximately 8,000 pieces.

Publications and Editorial Affairs

Joseph J. Hickey continued to serve the Society as Editor of THE JOURNAL OF WILDLIFE MANAGEMENT. He was assisted during the calendar year by a 15-man Editorial Board. Upon the recom-

TABLE 2.—STATEMENT OF RECEIPTS AND DISBURSEMENTS, 1958–59

RECEIPTS			
Bank balance February 14, 1958			$37,527.86
Receipts (deposited to checking account)			
Dues	$17,035.40		
Subscriptions	3,155.80		
Sales			
Back and single issues of THE JOURNAL	693.50		
Special publications	631.44		
Overrun on MONOGRAPH No. 1	200.00		
Overrun on MONOGRAPH No. 2	40.28		
Reimbursement on MONOGRAPH No. 1	1,000.00		
Other	35.00	$22,791.42	
Receipts (deposited to savings account)			
Dividends and interest	1,132.63		
Life-membership dues	2,225.00		
Paid article, Sport Fishing Institute	150.80		
Reimbursement on MONOGRAPH No. 2	918.57		
Memoriam to Arthur Sanger	25.00		
Advance on fisheries MONOGRAPH	500.00		
Miscellaneous	26.00	$ 4,978.00	$27,769.42
			$65,297.28
DISBURSEMENTS			
Publications			
THE JOURNAL OF WILDLIFE MANAGEMENT			
Printing	$10,416.36		
Editorial Assistance	1,396.75		
Editor's expenses (postage, stationery, etc.)	293.86		
SECOND TEN-YEAR INDEX TO THE JOURNAL			
Typing	42.57		
Editorial expenses	103.65		
Printing	1,795.50		
WILDLIFE MONOGRAPHS			
No. 1—printing	844.70		
—editorial costs	69.82		
No. 2—printing	805.20		
—editorial costs	78.51		
No. 3—printing	1,712.09		
—editorial costs	175.00		
Editor's postage and other costs	100.00		
WILDLIFE SOCIETY NEWS—printing	584.00		
TECHNIQUES MANUAL—preliminary run	686.35		
Maintenance of stencils, postage, and mailing of publications	1,331.19	$20,435.55	
Executive Secretary			
Clerical assistance	1,000.00		
Honorarium	700.00		
Travel and meeting expense	78.35	$ 1,778.35	
General supplies, printing and communications, inc. ballots, dues notices	1,454.90		
Meeting expense (awards, delegates, employment desk)	215.53		
Miscellaneous			
Affiliation dues (I.U.C.N.R., N.R.C., Int. Comm. Bird Pres.)	225.00		
Refunds, bad checks, bank charges	157.46		
Safety deposit box rental	5.50	$ 2,058.39	$24,272.29
Bank Balance February 22, 1959[1]			$41.024.99

[1] Books closed February 22, 1959 to permit auditing before annual meeting.

TABLE 3.—STATEMENT OF ASSETS AND LIABILITIES, FEBRUARY 22, 1959

ASSETS			
Cash			
Checking account (Kent County Bank)		$ 7,542.05	
Savings account No. 10282 (Bank of Silver Spring)		7,669.60	
Savings account No. 15147 (Bank of Silver Spring)		1,036.65	
Permanent fund (Emigrant Industrial Savings Bk.)		8,460.95	
Permanent fund (Perpetual Bldg. Assoc., S.S., Md.)		7,718.33	
Permanent fund (Loyola Federal of Baltimore)		8,597.41	$41,024.99
Securities			
44 shares State Street Investment Corp.		$ 1,633.72	
31 shares Loomis-Sayles Mutual Fund, Inc.		1,420.73	
U.S. Government Bonds Series G, 12-yr. Bonds			
Serial No.	*Cost*	*Date of Purchase*	
D-2576621G	$500.00	April 1947	496.00	
D-2576622G	500.00	April 1947	496.00	
D-2943626G	500.00	Sept. 1948	489.50	
D-2943627G	500.00	Sept. 1948	489.50	$ 5,025.45
Total assets				$46,050.44
LIABILITIES				
Liabilities				None
Net worth[1]				$46,050.44
Total liabilities and net worth				$46,050.44

[1] Excludes back issues and other publications of indefinite value.

mendation of an *ad hoc* Editorial Advisory Committee (consisting of G. A. Swanson, O. L. Hewitt, and H. B. Mills), the Editorial Board was expanded at the end of 1958 to include an Associate Editor for fisheries papers (Frank F. Hooper) and a Review Editor (Helmut K. Buechner). Thomas R. Evans continued his good work as Editor of WILDLIFE SOCIETY NEWS. He reports that worthwhile items continued to be received at a satisfactory rate.

During the calendar year, THE JOURNAL received 147 manuscripts (its largest number ever) and published 79 (its smallest number since 1950). Volume 22 of THE JOURNAL, the thinnest thus far put out by the Society, was of 10 per cent greater word-length than the thickest in 1952, which included the Farm-pond Symposium. The new JOURNAL, smaller in size but of greater word content, is the result of using thinner paper and a larger type bed. Rejections, withdrawals, and referrals of manuscripts to other periodicals amounted to 38 per cent for the second successive year. The backlog of manuscripts for our July issue, which amounted to an uncomfortable 16 on January 7, 1958, built up to a more workable 36 a year later. Reports to authors averaged 2 months after initial receipt of manuscripts, and publication averaged about 4 months after receipt of manuscripts revised by the authors.

The second 10-year Index to THE JOURNAL (compiled by O. B. Cope, G. H. Kelker, J. B. Low, and A. W. Stokes) was published last fall. The Society owes a great deal to these men, and particularly to Dr. Stokes, the committee chairman, for the prompt appearance of this valuable addition to THE JOURNAL.

WILDLIFE MONOGRAPHS, a new publication of the Society initiated last year, continues to prosper in spite of not having an assured means of financing. The first in the new series appeared in March under the title: *Field-feeding by Waterfowl in Southwestern Manitoba* by Eugene F. Bossenmaier and William H. Marshall. WILDLIFE MONOGRAPH No. 2, *Biology of the Great Plains Muskrat in Nebraska* by J. Henry Sather, was released in May. Third in the series, which appeared in December, was *Prairie Dogs, Whitefaces, and Blue Grama* by Carl B. Koford.

The Society is indebted to a number of organizations for financial assistance on WILDLIFE MONOGRAPHS. Sponsors for each issue were as follows: MONOGRAPH No. 1—University of Minnesota, Wildlife Management Institute, and Welder Wildlife Foundation; MONOGRAPH No. 2—Nebraska Game, Forestation and Parks Commission; and MONOGRAPH No. 3—New York Zoological Society and The Conservation Foundation.

During the year, 10 manuscripts were offered for consideration in the MONOGRAPH series. Half of these concerned fishery subjects and half involved birds and mammals. One classic fishery manuscript has been accepted for publication pending the availability of printing funds. Another, dealing with bighorn sheep, is assured of sponsorship and is approaching stages of final editing. Providing adequate financing can be arranged, four additional MONOGRAPHS will be published this year.

Louis A. Krumholz serves the Society as Editor of WILDLIFE MONOGRAPHS, having succeeded Werner O. Nagel, first Editor of the publication, who resigned last year.

Election of Officers, 1959–60

The Nominating Committee, under W. C. Glazener, nominated Charles A. Dambach and Oliver H. Hewitt for President, and Henry S. Mosby and Edward L. Kozicky for Vice-President. The first named were successful candidates.

Nominees for Regional Representative were as follows, the first named being the winning candidate: Region 1, Roger Latham and William R. DeGarmo; Region 2, Don H. Strode and Leslie L. Glasgow; Region 3, Jack H. Berryman and Bill T. Crawford; Region 4, Lee E. Yeager and Ralph R. Hill; Region 5, Wendell G. Swank and Eugene A. Walker; Region 6, Raymond F. Dasmann and Jessop B. Low; Region 7, David A. Munro and R. York Edwards. Ballots for nomination and election were counted and audited, as required.

Affiliations and Representation at Meetings

The Society continued its affiliation with the International Union for Conservation of Nature and Natural Resources, The Natural Resources Council of America, the International Science Foundation, and the American Association for the Advancement of Science. The Society became an affiliate this year of the International Committee for Bird Preservation. Society representation in various functions and organizations was as follows: Fred Dale—National Research Council; Dan Poole—Fifth National Watershed Congress at Dallas, Texas; John Aldrich—A.A.A.S.; Edward H. Graham and Lloyd W. Swift—I.U.C.N.N.R. in Athens, Greece; William H. Behle—Conservation Education Association; John M. Anderson—Waterfowl Advisory Committee of the Fish and Wildlife Service; and Lawrence V. Compton, Chairman of Technical Sessions for 24th North American Wildlife Conference.

Society Sections

All Sections continued to be active during the year, and meetings and conferences, as well as activities of members, have been reported in WILDLIFE SOCIETY NEWS. Current officers of the Sections were listed in the October issue of THE JOURNAL OF WILDLIFE MANAGEMENT.

Financial Report

Society books were closed on February 22 and audited on the same date. A detailed accounting of receipts and disbursements for the year, together with a statement of total assets and liabilities, is given in Tables 2 and 3. The auditor's report was turned over to the Trustees.—Respectfully submitted, J. P. LINDUSKA, Executive Secretary.

MINUTES OF THE WILDLIFE SOCIETY COUNCIL MEETING, MARCH 1, 1959

The Council met March 1, 1959, in the Statler-Hilton Hotel, New York City. The meeting was called to order by President Charles A. Dambach at 7:30 P.M. Other members present included O. H. Hewitt, Vice-President; A. Starker Leopold, Past-President, and regional representatives as follows: Roger M. Latham, Bill T. Crawford, Lee E. Yeager, Eugene A. Walker, and W. Winston Mair (alternate). Others in attendance as observers or advisers were: Harvey W. Miller, Wendell G. Swank, Jack H. Berryman, Louis A. Krumholz, Henry S. Mosby, Thomas R. Evans, Joseph J. Hickey, and the Executive Secretary.

As the first item of business, President Dambach called for a report on progress and plans for publishing the TECHNIQUES MANUAL. Henry Mosby stated that the comments on the first draft of the manuscript were generally complimentary and a number of constructive suggestions had been received. He reviewed in some detail the possibilities for publishing the manual and the costs involved. C. R. Gutermuth commented on the desirability of the Society taking a more active part in the preparation and publication of such technical manuscripts. He added that several members of the Wildlife Management Institute staff had reviewed the TECHNIQUES MANUAL and felt that it would constitute a worthwhile publication. Mr. Gutermuth then informed the Council of his preliminary negotiations with the Stackpole Company relative to publication. Assuming a book-length product of 336 pages and a printing of 3,000 copies, the retail price would come to $9.00. It was generally agreed that such a price would limit distribution, and the Council was favorable to Mr. Gutermuth's suggestion that the Society subsidize publication to reduce the buying price to around $5. When put to a vote, the Council agreed that the Society should underwrite publication costs to the extent of $2,500 and through the Wildlife Management Institute co-publish the manual with the Stackpole Co. Mr. Gutermuth offered to solicit sponsorship of illustrations for the book at an estimated cost of $500. President Dambach requested Henry Mosby to hasten completion of the work and to proceed with the Institute in arranging for publication.

The Executive Secretary was then called upon for a report of Society affairs. A detailed processed report having been made available to the group, discussion was limited to a brief summary of membership status and pertinent financial affairs. An analysis of the growing work load in the office of Executive Secretary was offered, and there followed a discussion of means for easing the seasonal pile-up

of duties. Since our current financial structure will not permit, and the year-round work load does not justify the employment of a full-time paid staff, other solutions were considered. A number of minor duties currently handled by the Executive Secretary's office are of a nature that could be carried by permanent one-man committees. It was agreed, therefore, that the Executive Secretary should work with the President to effect a relegation of responsibilities through appointment of minor committees.

Editors of Society publications were invited to comment on their work, and J. J. Hickey summarized JOURNAL affairs over the past year. The publication of a membership list was discussed, and it was moved by Leopold, seconded by Krumholz, that such a list should be published this year at an approximate increased cost of JOURNAL publication of $900. The motion carried.

Louis Krumholz outlined developments with reference to the MONOGRAPH series. Ten papers have been offered for publication, and two of these (one on fish and one on mammals) have sponsorship reasonably assured. Mr. Krumholz suggested that a finance committee be appointed to solicit publication funds for the MONOGRAPHS.

Thomas Evans remarked on WILDLIFE SOCIETY NEWS, stating that submittal of items was reaching him at a satisfactory rate. He suggested that the NEWS could serve a good function in publicizing job opportunities and indicated he would write to the State Fish and Game Departments asking that copies of Civil Service announcements be forwarded directly to him.

President Dambach reported on the completion of the handbook, "Making Your Technical Writing Useful." He obtained concurrence of the Council to have the Society appear as joint sponsor of the publication with the American Fisheries Society and the National Wildlife Federation, which will underwrite publication and distribution.

Consideration was then given to a method of publication of the Employment Committee's report on "Training and Employment of Wildlife Biologists and Fisheries Biologists." On a motion by Latham, seconded by Crawford, the Council agreed to publish the report in THE JOURNAL and to obtain 5,000 reprints for distribution and sale.

Following a review of the Society's affiliations and representations, it was moved by Yeager and seconded by Hewitt that all current connections be maintained and that we participate as sponsor of the National Watershed Congress at a cost of $100 per year.

Philip L. Wright reviewed the history of the Northwest Section of The Wildlife Society and requested recognition of a newly constituted section to include Oregon and Alberta. It was determined that the Section, already having been recognized by the parent Society, could add to or subtract from its state and provincial representation without referral to The Wildlife Society Council. A discussion of our regional boundaries followed, and it was agreed that the Bylaws Revision Committee should consider the adequacy of our present regional structure.

TABLE 1.—BUDGET FOR 1959–60[1]

Publications	
JOURNAL, printing	$11,500.00
NEWS, printing	600.00
Maintenance of stencils, postage, mailing of publications, storage, etc.	1,500.00
MONOGRAPHS—Editorial, printing, and mailing (reimbursable)	4,000.00
—Purchase for resale	300.00
Editorial expenses	
JOURNAL	
Miscellaneous—supplies, postage, etc.	350.00
Editorial assistance	1,200.00
MONOGRAPHS	
Miscellaneous—postage, communications	100.00
Honoraria for editors	600.00
Executive Secretary	
Clerical assistance	1,000.00
Secretarial assistance (seasonal)	400.00
Honorarium	700.00
Travel and meeting expense	200.00
General supplies, printing and communication, postage, mailing of ballots, dues notices, etc.	1,500.00
Meeting expenses (delegates, awards, employment desk)	150.00
Miscellaneous charges (audit, refunds, and bad checks)	150.00
Affiliations	250.00
Insurance	235.00
Contingency fund	600.00
TOTAL	$25,335.00
(Less reimbursement in full for MONOGRAPHS)	4,000.00
Net operating expense	$21,335.00

[1] Based on anticipated income (excluding investment income) of $22,000.00.

The Executive Secretary reviewed budget proposals for the coming fiscal year. Hewitt moved, seconded by Leopold, that each of the Editors be provided with a small honorarium of $300 for the JOURNAL editor, $200 for the MONOGRAPHS editor, and $100 for the NEWS editor. Following these additions and other minor revisions of the budget, it was moved by Leopold, seconded by Yeager, and voted by the Council that the budget for the coming year in the amount of $21,335 be approved.

Following on the expiration of E. R. Kalmbach's term as Trustee, it was moved by Leopold, seconded by Hewitt, and voted by the Council that Arnold L. Nelson be appointed to succeed Kalmbach.

The Council heard recommendations for honorary membership and endorsed, for consideration at the annual meeting, the election of Stanley P. Young and A. G. Huntsman.

On a motion from Hewitt, seconded by Leopold, the Council approved appointment of Charles M. Kirkpatrick to succeed Joseph J. Hickey, who resigned from the editorship of THE JOURNAL upon the appearance of the July 1959 issue. Editors of WILDLIFE SOCIETY NEWS and WILDLIFE MONOGRAPHS and the Executive Secretary were retained in office by appropriate action of the Council.

Jack Berryman then presented a number of proposals of the Minnesota section for strengthening the Society. Following considerable discussion, Leopold offered a motion, which was seconded by Latham and voted unanimously, to the effect that a committee be appointed to develop a code of ethics. It was further agreed that other recommendations of the Minnesota section be presented to the annual meeting and publicized through the NEWS and other means, and that, if general support is indicated, the Bylaws Committee formulate appropriate proposals and ballot the membership. The motion carried.

On a motion by Leopold, seconded by Yeager, the Council approved entering into arrangements with the Johnson Reprint Company to have them reprint for sale the out-of-print numbers of THE JOURNAL OF WILDLIFE MANAGEMENT.

The President then appointed a committee of Yeager, Crawford, and Hewitt (chairman) to prepare two resolutions for presentation to the membership at the annual meeting.

The Council meeting was adjourned at 2:30 a.m., March 2, by President Charles M. Dambach.—Respectfully submitted, J. P. LINDUSKA, Executive Secretary.

MINUTES OF THE ANNUAL BUSINESS MEETING, MARCH 2, 1959

The twenty-third annual business meeting of The Wildlife Society was held March 2, 1959, in the Penn Top South room of the Statler-Hilton Hotel, New York City. Both the annual meeting, with more than 200 present, and the annual banquet, with well over 100, were well attended. A customary feature of the banquet was the presentation of the Society's Publication and Conservation Education Awards, the details of which appear elsewhere in this issue of THE JOURNAL.

President Charles A. Dambach called the meeting to order shortly after the scheduled hour of 8:00 P.M. The order of business followed that prescribed by Section 2, Article 8 of the Society's Bylaws. On a motion by Gustav A. Swanson, seconded by W. C. Glazener, the membership approved the minutes of the last annual meeting, which were published in THE JOURNAL OF WILDLIFE MANAGEMENT, 22(3): 296.

The Executive Secretary remarked briefly on highlights of Society affairs during the past fiscal year and referred the members to copies of the annual report available in the meeting room.

President Dambach then summarized the activities and accomplishments of his office during the year. Particular mention was made of the Society's efforts to implement Resolution No. 2 of the last annual meeting, which urged that efforts be made to up-grade the biological sciences and to stimulate a greater public interest in our profession of resource management. He stated that letters from his office had brought a sympathetic response from President Eisenhower and the Chairman of the National Civil Service Commission. President Dambach then presented in brief some of the actions of the Council in their meeting the previous evening and called upon the Executive Secretary for a reading of the minutes.

Council actions requiring endorsement by the membership were then discussed. On a motion by Wendell Swank, seconded by Lee Yeager, the body approved unanimously the Council's recommendation of honorary membership for Stanley P. Young and A. G. Huntsman.

The President then remarked briefly on the Society awards, which were announced earlier at the banquet, and invited committee chairmen to comment further on their work. Kenneth Hungerford reaffirmed the wisdom of the awards committee standards in permitting the consideration of publications over a 2-year period. Charles Kirkpatrick remarked on activities of the Employment Committee and referred to its report for details of accomplishment. He suggested that employment statistics be compiled and reported only every 3-5 years. Mr. Kirkpatrick also raised the question as to whether or not such a service is a logical function of the Society, pointing out that fewer than half of the 57 job applications received came from members of the Society. C. R. Gutermuth was highly complimentary of the Employment Committee's work over the years and felt that it was providing a genuine service. He felt strongly that it was an extremely important function for the Society to perform. Lee Yeager spoke briefly of the Membership Committee's work and referred to the annual report of the Executive Secretary for details of accomplishment. W. C. Glazener told of the work of the Nominations Committee and stated that tradition had been interrupted by nomination of the incumbent President for a second term.

President Dambach remarked on the completion of the Second 10-year Index to THE JOURNAL, the Membership Brochure, and the initial draft of the TECHNIQUES MANUAL. He acknowledged the work of committees responsible for these accomplishments

and also extended thanks to other committees that were active during the year in the interests of the Society.

Reporting on the work of the Committee on Bylaws Revision, Gustav Swanson told of five important considerations that have been presented to the committee and that had engaged their attention during the year. He invited the membership to offer other suggestions and to provide the committee with reactions to existing proposals.

A reading of reports from Regional Representatives was dispensed with, following approval of an appropriate motion by Lee Yeager, seconded by George D. Aiken.

There followed a brief report on the accomplishments of the Committee appointed to review and implement Resolution No. 2 of the last annual meeting. The chairman noted that the purpose of the resolution was to urge a greater prestige and financial reward for workers in the profession. Limitations under which the Committee worked and its accomplishments were summarized briefly.

Vice-President O. H. Hewitt read two resolutions of the Council, which were passed by the membership. The first was an expression of thanks to the Wildlife Management Institute for their usually effective job in making arrangements for the Society's activities at the Conference and to the Hotel Statler-Hilton for their co-operation and courtesies. A second resolution acknowledged the excellent work of Joseph J. Hickey over a 3-year period when he served the Society as its Editor of THE JOURNAL OF WILDLIFE MANAGEMENT.

Under the agenda item of new business, President Dambach introduced a report of the Minnesota section of The Wildlife Society and called on Jack Berryman to review the proposals. Berryman read briefly from a report previously published in WILDLIFE SOCIETY NEWS and referred interested members to that publication for details. In brief, the proposals called for adoption of a professional code of ethics, a graded membership such as would enlarge upon the professional status of the Society, and a full-time executive officer empowered to speak for the Society on issues of the day. A lengthy discussion followed, in the course of which the President called upon Starker Leopold to cite what might appear as obstacles to implementing the proposals.

Winston Mair spoke in favor of a professional society in place of "just a society" and expressed confidence that the old problems associated with a classified membership should not be of great concern. He favored a substantial raise in dues to underwrite a broader program by the Society.

Earl Frye remarked on the desirability of having permanent paid officials in place of changing committees to handle some affairs of the Society.

President Dambach reviewed for the audience the procedures being followed in other professional organizations, particularly as regards types of membership, dues, and costs of operation. Upon invitation from the President, Henry Clepper of the Society of American Foresters reviewed historical events in the development of their organization. Following his comments on professionalism, he recommended for reading by the group, the book, *Education for the Professions* by Dr. Lloyd Blanch. Mr. Clepper and E. A. Seaman (American Fisheries Society) then told of the effects on enrollment of dues increases in their respective organizations.

In response to an inquiry by V. L. Flyger concerning affiliation with A.I.B.S., President Dambach told of the careful consideration given the matter by the Council. After quoting the costs of various classes of affiliation, he explained the necessity of the Council's action in keeping within budget limitations.

The President then voiced a word of caution in adopting sweeping changes in the Society's objectives, membership, and basic structure. He informed the group that the Bylaws Committee had been instructed to review all such matters as were heard at the annual meeting and that the various proposals would be brought to the attention of the full membership through WILDLIFE SOCIETY NEWS and other media. Following a test of sentiment by these means, a polling of the membership on specific proposals would then be necessary to effect the changes.

There being no further business, the meeting was adjourned by President Dambach at 10:30 p.m.—Respectfully submitted, J. P. LINDUSKA, Executive Secretary.

ANNUAL REPORTS OF WILDLIFE SOCIETY COMMITTEES

The Aldo Leopold Award[1]

The presentation of this award was made for The Wildlife Society by President Charles A. Dambach at the annual banquet of the 24th North American Wildlife Conference, as follows:

"The Wildlife Society established in 1950 a bronze medal bearing the name and likeness of the late Aldo Leopold. This medal is presented annually, by the Society, in recognition of the highest achievement in service to wildlife conservation. It is significant that the person to whom the medal is to be presented this year was a close friend and admirer of the man in whose memory this award was established.

"Selection of the person to receive this honor rests with a committee of The Wildlife Society,

[1] Previous recipients of the award were J. N. Darling (1950), Carl D. Shoemaker (1951), Olaus J. Murie (1952), Ira N. Gabrielson (1953), Harold Titus (1954), Clarence Cottam (1955), Hoyes Lloyd (1956), C. R. Gutermuth (1957), and E. R. Kalmbach (1958).

ERNEST F. SWIFT
Recipient of The Aldo Leopold Award in 1959

which this year included Ben Glading of California, Edward L. Kozicky of Illinois, William H. Marshall of Minnesota, Wendell G. Swank of Arizona, and Arthur S. Hawkins of Minnesota, Chairman.

"The committee selected a man who has been dedicated to wildlife conservation for half a century —one who has been the defender of wildlife in the lonely northern forests of his home state during an era of rampant lawlessness in the out-of-doors and in the equally lonely but crowded legislative halls where ignorance, malice, and prejudice often stood in the way of progressive wildlife-conservation programs.

"As chief administrator of the conservation department in the state to which his ancestors migrated more than a hundred years ago, he pioneered a program of wildlife management based on the findings of trained fish and game biologists.

"During his many years in key administrative positions, he served the interests of wildlife conservation nation-wide in many ways. Included in these services are Chairmanship of the National Waterfowl Council (1953–54), President of the Midwest Association of Fish, Game and Conservation Commissioners, Chairman of the Executive Committee (1952–53) and 2nd Vice-President (1953–54) of the International Association of Game, Fish and Conservation Commissioners, and committee assignments for the American Fisheries Society and the Society of American Foresters.

"Logic expressed on the speaker's platform and on the printed page have been effective tools in his trade.

"Since 1954 when he moved to Washington, first as Assistant Director of the U.S. Fish and Wildlife Service and now as Director of the National Wildlife Federation, his crusade has been extended to every part of the United States and to foreign shores. Those of you who have been privileged to read his challenging stories ("The Glory Trail," "By Which We Live") and his editorials in *Conservation News* undoubtedly now realize that the Aldo Leopold Award this year is to be presented to Mr. Ernest F. Swift. If Mr. Swift will please come forward, I will, on behalf of The Wildlife Society, present this medal to him.

"Ernie, may I, in presenting this medal to you, express appreciation in behalf of The Wildlife Society for the distinguished service you have rendered the cause of wildlife conservation as an administrator, a philosopher, and an outstanding leader among your fellow men. May I add, too, my personal best wishes to you and Mrs. Swift on this signal occasion."

Conservation Education Award

The Conservation Education Award Committee, after careful evaluation of the 19 nominations received which cover three categories—publications and journalism, films, and conservation-education programs, has selected Dr. Fred J. Schmeeckle as recipient for the 1958 award.

Dr. Schmeeckle has been chosen because of his lifetime service in connection with conservation education and for establishing and developing a model conservation program at Wisconsin State College—a program which has long been recognized as the nation's pioneer in conservation education. Under his outstanding leadership, this department has made phenomenal growth since its modest beginning in 1945.—Respectfully submitted, J. C. CULBREATH, R. K. DAVIS, G. W. MCCULLOUGH, AND J. J. SHOMON, Chairman.

Fisheries Publication Award

Two of the many fishery publications studied by the Committee were outstanding. We recommend that duplicate awards be given to Milton B. Trautman for *The Fishes of Ohio* (The Ohio State University Press, 1957) and to Raymond J. H. Beverton and Sidney J. Holt for their *On the Dynamics of Exploited Fish Populations* (Ministry of Agriculture, Fisheries and Food, Fishery Investigations, Series 2, Volume 19; Her Majesty's Stationery Office, London, 1957).

The Committee solicited aid, by personal letter and mimeograph announcement, from each of the Regional Representatives, the 15 leaders of the Cooperative Wildlife Research Units, officials of the 48 state fish and game commissions, and 16 representatives of various Canadian fishery agencies. We thank those who responded.—Respectfully submit-

ted, PAUL H. ESCHMEYER, JOHN S. GOTTSCHALK, W. E. RICKER, J. H. WALES, AND W. HARRY EVERHART, Chairman.

Terrestrial Wildlife Publication Award

The unanimous choice for the Terrestrial Wildlife Publication Award was the work of Howard L. Mendall, *The Ring-necked Duck in the Northeast,* published in 1958 as University of Maine Bulletin, vol. 60, no. 16. The committee agreed that this work is an outstanding example of a well-written report based on long-time, deep-digging field research.

Your committee recognizes two other outstanding publications of 1958 in awarding Honorable Mention to Richard D. Taber and Raymond F. Dasmann for their *The Black-tailed Deer of the Chaparral* (Game Bulletin No. 8, California Dept. of Fish and Game) and to Victor B. Scheffer for his *Seals, Sea Lions and Walruses—a Review of the Pinnipedia* (Stanford University Press).

Your committee was impressed with the large number of high-quality scientific works in the wildlife field during 1958. Many of these publications bear low numbers in technical bulletin series recently started by state organizations. We commend both the wildlife scientists responsible and the administrators for their foresight and wisdom in completing publication plans. This year has also seen the first publications in the Wildlife Monograph series of the Society. We commend the officers and editors of our Society and the authors and sponsors of these monographs. A high standard has been set for those to follow.

We reaffirm the wisdom of the Awards Procedure as set up in 1955, especially in providing two years during which a publication may be considered.—Respectfully submitted, DOUGLAS H. PIMLOTT, JAMES H. JENKINS, ROBERT A. MCCABE, WILLIAM H. STICKEL, AND KENNETH E. HUNGERFORD, Chairman.

Bylaws Revision

This report of progress of the committee's deliberations does not include any specific recommendations for action by the Society at this time. President Dambach has asked the same committee to continue for another year, and we should like, therefore, to have this progress report constitute also an invitation to all members to express their views to us on any matters of importance to the Society that might involve changes in the Bylaws. The following questions have come to our attention, as being in need of consideration, and in each case changes in the Bylaws would be required if any changes in the Society's practices were to occur:

1) Should the composition of the Council, the governing board of the Society, have greater continuity through longer and overlapping terms for its regional representative members? And should there be any limitation on the length of time served by a Council member? At present, the Executive Secretary is elected by the Council for an indefinite number of years and attends its meetings as an adviser. The Past President is also a member of the Council. All other members are elected annually, and theoretically could all be replaced in a single year. There is no limitation at present on the number of annual terms a regional representative may serve.

2) Can the present system for nominating regional representatives be improved upon?

3) Should the Council be enlarged by including some members-at-large, instead of having all elected as regional representatives?

4) Should there be further provision for our increasing number of foreign members to participate in the affairs of the Society? Since they do not belong to any region, they are not qualified to vote for any regional representative, although they do vote for the officers. If Council-members-at-large were added, foreign members of course could vote for them.

5) Is it time again to consider the difficult matter of making the Society more definitely a professional society? This would involve debating issues that have been hotly debated before, such as providing definite qualifications for membership, and providing for sufficiently high dues so that the Society could employ some full-time staff members. The Minnesota and Canadian sections have given much thought to these matters during the past couple of years and have very definite opinions on them.

These are the more important of the subjects that the committee has been considering during the past year, but without coming to any definite recommendations. Reactions of Society members on these matters, and suggestions for others, will be welcome. —Respectfully submitted, DANIEL L. LEEDY, JUSTIN W. LEONARD, GEORGE A. PETRIDES, A. STARKER LEOPOLD, AND GUSTAV A. SWANSON, Chairman.

Employment

Questionnaires relative to *college enrollments* and *graduates* were sent to 81 educational institutions offering training in fisheries and wildlife biology. Replies were received from 42 (Table 1). Because the schools reporting and the total number reporting vary from year to year, a comparison of total reported enrollments in different years is not believed to be valid. Therefore, 37 schools with complete and comparable reports for 1957–58 and 1958–59 were selected and summarized. A comparison showed a total of 1,998 students in 1957–58, and 2,216 students in 1958–59, an increase of 10+ per cent in total enrollment over 1957–58. An innovation in this year's committee report is the tabulation of enrollees as fishery or game majors, a change which we hope will make this part of the report twice as useful.

The *employment history* of 438 men who were 1957–58 graduates is shown in Table 2. An analysis of the data reveals that 45 per cent of the B.S. graduates, 68 per cent of the M.S. graduates, and

79 per cent of the Ph.D. graduates received employment in wildlife or related work. Percentages of B.S. and M.S. graduates staying in school were comparable to immediate past years. Of 254 persons whose employment was known, 57 per cent were employed by states and provinces, 24 per cent by federal agencies, 12 per cent in wildlife teaching, and 7 per cent by private agencies and individuals. Percentages of graduates receiving various types of degrees in 1957–58 (64 per cent, B.S.; 27 per cent, M.S.; and 9 per cent, Ph.D.) have remained approximately the same for the past several years.

Standard questionnaires requesting *employee turnover* and *employer opinion* information were answered by 53 state and federal agencies and 6 private organizations for a 21 per cent total return of the questionnaire. Tabulations reveal that during 1957–58: (1) Replacements included 84 fisheries personnel, 56 game, 138 enforcement, and 18 information; (2) new permanent appointments included 47 fisheries personnel, 43 game, 34 enforcement, and 15 information; (3) seasonal employees included 853 fisheries personnel, 319 game, 365 enforcement, and 92 information.

Estimates by 51 state, provincial, and territorial agencies as to their future needs were: game men— 25 to increase, 16 to remain the same; enforcement men— 15 to increase, 1 to decrease, 26 to remain

TABLE 1.—DISTRIBUTION OF STUDENTS ENROLLED IN FISHERIES AND WILDLIFE CURRICULA, 1958–59

Name of Institution	Below Senior	Senior	M.S.	Ph.D.	Special	Total	Option	
							Fisheries	Game
Alaska, Univ.	27	3	2	–	2	34	–	34
Arizona, Univ.	26	20	4	–	1	51	1	50
British Columbia, Univ.	–	–	20	20	–	40	21	19
Calif., Univ. (Berkeley)	4	11	5	9	–	29	–	–
Calif., Univ. (Los Angeles)	–	4	2	7	–	13	–	13
Calif. State Poly. Coll.	12	5	–	–	–	17	1	2
Colorado State Univ.	41	24	14	–	–	79	26	53
Connecticut, Univ.	13	6	4	–	1	24	8	16
Cornell Univ.	65	13	18	19	18	133	11	8
Florida, Univ.	2	3	–	–	–	5	–	5
Georgia, Univ.	32	8	6	7	–	53	1	52
Humboldt State Coll.	129	69	8	–	–	206	65	141
Idaho, Univ.	13	7	6	–	–	36	9	27
Illinois, Univ.	–	–	4	1	–	5	1	4
Iowa State Coll.	34	5	9	6	–	54	–	–
Indiana, Univ.	–	–	1	4	–	5	5	–
Kansas, Univ.	–	–	12	8	–	20	8	12
Kansas State Univ.	4	4	3	–	–	11	–	–
Louisiana State Univ.	–	–	4	–	2	6	–	6
Maine, Univ.	24	11	5	–	–	40	5	35
Miami, Univ. (Fla.)	49	–	31	–	–	80	–	–
Michigan State Univ.	110	15	22	8	4	159	–	–
Michigan, Univ.	20	17	12	12	2	63	22	41
Missouri, Univ.	61	11	14	3	–	89	8	9
Montana State Coll.	52	5	12	2	–	71	–	–
Montana State Univ.	47	16	8	–	–	71	–	–
New Hampshire, Univ.	12	8	–	–	–	20	–	20
No. Carolina State Coll.	37	13	6	1	–	57	–	–
Ontario Agric. Coll.	6	7	4	–	1	18	6	12
Oregon State Coll.	146	50	18	–	–	214	52	162
Penn. State Univ.	–	–	11	3	–	14	–	–
Purdue Univ.	4	–	1	2	–	7	–	7
Rhode Island, Univ.	1	1	2	–	–	4	4	–
Syracuse, Univ.	–	–	8	4	–	12	3	9
Texas A. & M. Coll.	58	13	1	2	–	74	7	66
Texas, Univ.	–	–	2	–	–	2	2	–
Utah State Univ.	115	34	22	7	3	181	–	–
Virginia Polytech. Inst.	66	8	7	2	–	83	–	9
Wash., Univ. (Sch. Fisheries)	51	25	22	16	6	120	120	–
Wash. State Coll.	19	7	6	1	–	33	–	–
Wisconsin, Univ.	–	–	13	11	–	24	16	8
Wyoming, Univ.	23	7	5	1	–	36	–	–
Totals (42 schools)	1,303	440	354	156	40	2,293	407	829

TABLE 2.—EMPLOYMENT SELECTION BY 1957–58 GRADUATES ACCORDING TO DEGREE RECEIVED

Employment Category[1]	B.S.	M.S.	Ph.D.	Total	Per Cent
Game research	11	16	6	33	8
Game management	42	17	–	59	13
Fish research	20	23	10	53	12
Fish management	31	14	3	48	11
Game and fish research and management	6	10	–	16	4
Law enforcement	5	–	–	5	1
Public relations	4	3	–	7	1
Teaching fish, wildlife, related courses	2	5	12	19	4
Other teaching	3	4	6	13	3
Back in school	71	27	1	99	23
Military service	36	1	–	37	9
Unknown	21	2	–	23	5
Other employment	18	7	1	26	6
Totals	270	129	39	438	100

[1] Employment (based on 254 students) by type of agency: state or provincial, 146; federal, 62; educational institutions, 30; and private organizations, 16.

the same; fisheries men—26 to increase, 20 to remain the same; information personnel—18 to increase, 18 to remain the same. Most states reporting have residence requirements for conservation officers (enforcement), but only a few have residence requirements for other personnel. Ten states did not return the questionnaire.

In the six private-organization responses, virtually no anticipated increases in staffs were indicated.

Among 34 potential employers expressing opinions on the principal educational deficiencies of applicants or new employees, 56 per cent (55 per cent two years ago) listed weakness in use of English, mainly writing; 41 per cent listed lack of public-relations knowledge; and 20 per cent reported a lack of adequate training in mathematics and/or statistics. The many other needs cited were of minor frequency and tended to cancel each other out, e.g., not enough science courses vs. too much science, etc.

Regarding opportunity for college-trained men as conservation officers, 67 per cent (83 per cent two years ago) of 45 organizations answering anticipated increased opportunity, but several states so replying said their wardens' salaries are not attractive to college graduates; hence, opportunity is not increased in those states and perhaps in some of the others.

As in the past, considerable effort was devoted by the committee during the year to *employment service* to employers and applicants seeking employment. All persons having applications on file in March 1958 were contacted in the summer in order to bring our applicant file up to date. The names of active applicants, and new applicants received during the year, were separately listed into areas of interest, i.e., game, fisheries, and information. Copies of these lists were sent to all agencies listing vacancies, and were also made available at the Midwest and North American wildlife conferences. Two lists of vacancies reported by agencies were developed during the year and sent to all applicants. By this listing and referral service, about 1,500 potential applicant–employer contacts were created. In addition, a number of requests from applicants and employers were handled individually. Notices drawing attention to the existence of the committee, its function, and lists available were sent twice to WILDLIFE SOCIETY NEWS. An employment desk was operated at the Columbus Midwest Wildlife Conference. Time expended by the committee in this kind of service is mostly unrewarded. The committee rarely receives notice that an applicant found a job or that an agency filled a vacancy, necessitating periodic, laborious canvasses to improve the efficiency of the lists. Therefore, the committee's policy is to discard an applicant's file after 1 year unless he is heard from.

In response to a suggestion made several years ago by President Allen, the committee placed with President Dambach the rough draft of a *manuscript on training and employment* of wildlife and fishery biologists. The manuscript is intended as an introduction for the prospective student to wildlife and fisheries management.

The first consideration of this year's committee was to review its function and take note of the stereotyped form its reports have taken. Several "feelers" were put out to past and present officers and others about the value of gathering annual statistics. Specifically, are figures on enrollment, employment of graduates, and employee turnover useful? The general thinking was that only the inventory of enrollment justified the effort given to collecting the data, with several persons suggesting that enrollment figures available once in every 3–5 years would be sufficient for comparing trends. The wisdom of this suggestion is supported by the similarity of reports from year to year. Trends in wildlife enrollments are probably proportional to total college enrollments.

The committee questions whether the liason service between applicants and employers has essential value to the Society. As it exists now, the service amounts to free, classified advertising at the expense

of time, materials, and postage of committee members or their indulgent employers. If such contributions of time and funds are justified, some advantage over the individual applicant's responsibility to search for jobs ought to be evident. So far as the committee is aware, no real advantage has been shown, especially since no acknowledgment of "assists" are received. The active applicant lists contain names of persons already employed, who are shopping for different jobs, some of whom are not Society members. Some employment activity, perhaps most of it, goes on without need for committee service, not only in higher-echelon positions but at beginner's level as well. These experiences lead the committee to believe that, if an employment service is necessary, a more effective medium would be THE WILDLIFE SOCIETY NEWS. Individuals who place a value on such advertising as they now receive free of charge would be willing to pay for notices to offset handling and printing costs. A much wider circulation of employment information at regular intervals would result, and time-consuming committee work would be reduced. The committee recommends that the Council give consideration to use of the NEWS for employment listings on a paid notice basis.

In recommending publication of its special report on training and employment, the committee suggested that the publication would have value if distributed by the Society, or sold at cost to institutions or conservation agencies who have need for such a publication. Recipients would be prospective students and others who inquire about opportunities in fishery and wildlife biology.—Respectfully submitted, O. E. FRYE, JR., JAMES W. KIMBALL, ALLAN T. STUDHOLME, GEORGE J. TURNER, JR., AND CHARLES M. KIRKPATRICK, Chairman.

Membership

As in 1957–58, the Membership Committee of The Wildlife Society in 1958–59 consisted of the seven Regional Representatives. Organization in the provinces and states likewise adhered to custom in the appointment of a chairman or leader in each commonwealth, nearly all of whom perfected local organizations of one sort or another. Thus, each province and state developed its own Membership Committee and operated under the general leadership of the Regional Representative of its respective region. These teams solicited new members—fish and wildlife students, game and fish department personnel, and other groups—on a more or less organized basis. The development of such organizations began in the spring and continued, in some states, into the winter.

Results

Due to the constantly changing pattern in the membership rolls of the Society, induced by new enrollments, delinquency in payment of dues, and changes of address, it is impractical to keep fully up to date concerning the status of the membership campaign during the year. For this reason, and also because membership solicitation is made by many —Society officers, the Executive Secretary, the Membership Committee, and others interested— who usually send applications and remittance directly to the office of the Executive Secretary, it is not possible to give here a precise, state-by-state, accounting of campaign success. The Executive Secretary has, however, advised that a total of 388 new (regular) members were enrolled by all solicitors in 1958, almost identical to the enrollment of 389 new members in 1957. Many, and perhaps most, of these additions were the results of efforts on the part of some 100 individuals assisting in the membership campaign. The Committee is further advised that the present rate of recruitment is running well ahead of that of last year.

In 1958, the Membership Committee used to much advantage a brochure describing the objectives of The Wildlife Society, prepared by Durward Allen, Charles Schwartz, Douglas Wade, and Lee Yeager. Although this material was not received until late in December, there appears to be no question of its effectiveness; it is anticipated that full-time availability of this aid in 1959 will contribute appreciably to the success of subsequent recruitment activities.

Policy

The old question of Society standards was brought up in various states during the campaign. There was also the companion question: How far should the Membership Committee go in soliciting prospective affiliates?

This question obviously involves standards as well as approaches, including the somewhat touchy problem of *who* should belong. Officially, of course, membership in The Wildlife Society has been sanctioned for anyone with an interest in this broad field. But inevitably some members—and in some instances, nonmembers—question the propriety of soliciting individuals with only a commercial or popular interest in wildlife resources. Certainly in some cases prospective members, thinking of the Society as a professional proposition, have expressed skepticism at joining an organization open to everyone, with no provision for maintaining what they construe as standards in a professional society.

In view of the bylaws covering membership, it is clear that any member may properly invite any interested individual to join the Society. But is it in the best interest of The Wildlife Society, particularly if it poses as a *professional* organization, to make concentrated efforts at enrolling individuals of doubtful affinity? Experience has shown that the percentage of subsequent-dues delinquency in such groups is large, and that repeated entreaties to honor dues notices are often ignored. Enrollment of relatively noninterested members, through selling techniques, has proven to be expensive of postage and secretarial time after the first year, and appears to have led to some embarrassment of both members and the Society organization.

The Membership Committee, on the advice of a majority of its members, requests the Council to consider recommendations Nos. 2–5 in its 1957–58 report, in order to guide the committee in its membership campaigns in the future.

Acknowledgments

To the more than 100 individuals serving in every province and state, and to whom fell the great load of work incident to the 1958–59 membership campaign, we extend our sincerest appreciation. Likewise, we appreciate the many courtesies extended during the year by Society officers, the Executive Secretary, and many interested members. It was, indeed, the teamwork between field representatives and the Executive Secretary of the Society that, to large measure, made possible any success that may have been attained in the membership campaign this year.—Respectfully submitted, ROGER M. LATHAM, REGION I; E. B. CHAMBERLAIN, Region II; BILL T. CRAWFORD, Region III; EUGENE A. WALKER, Region V; RAYMOND F. DASMANN, Region VI; DAVID A. MUNRO, Region VII; AND LEE E. YEAGER, Region IV, Chairman.

Status of the Biological Sciences

This committee was brought into being for the purpose of exploring means of (1) securing greater professional recognition for workers in the life sciences, and (2) of ". . . stimulating greater public interest in the imperative need of maintaining an equality and equilibrium between the basic sciences, and in the fundamental necessity of having adequate and proportionate shares of professional wildlife biologists in appropriate technical and administrative positions." Committee appointment followed on the presumption, in part, that wildlife workers enjoyed a lesser prestige and lower pay than other professions and skills requiring similar or less training.

As a starting point, the committee attempted to seek out information to establish the degree of disparity between wildlife positions and other types of work. In this connection it was evident that little of value is gained by comparisons of this or other professional work with skilled labor in private industry. For one thing, high hourly rates, computed to annual levels, may distort the picture in favor of the journeyman. But professional workers, on the other hand, normally enjoy continuity of employment and job extras not revealed in the basic pay structure.

In comparing pay rates of wildlife workers with those in other professions, several surveys recently completed have been especially revealing. Within the year the National Wildlife Federation compiled and published "Compensation in the Fields of Fish and Wildlife Management in 1958." The Wildlife Management Institute reported on a "Comparison of State and Private Wildlife Salaries in the Western United States." This information, being available from the Federation and the Institute, is not shown here.

Results of another survey by the Public Personnel Association of Chicago, Illinois, were reported in July 1958 under the title, "Pay Rates in the Public Service." Selected data from this source are shown in Table 1. Job descriptions for the various positions (except carpenter) in this table indicate a requirement for specialized training that is comparable for the several specialties.

The Federation survey takes note of the fact that competition from private industry serves to build the salary levels for some fields of specialty. This has been to the advantage of professionals in the physical sciences. Biologists in resource management do not enjoy the same brisk competition for

TABLE 1.—COMPARATIVE PAY RATES IN PUBLIC EMPLOY, JULY 1958[1]

State or Province	Game Biologist	Forester	Bacteriologist	Psychiatric Social Worker	Personnel Technician	Clinical Psychologist	Carpenter
Maine	355–442	338–425	373–465	338–425	312–390	390–485	260–325
Connecticut	350–470	—	275–395	350–470	445–605	350–470	275–395
New York	395–470	395–470	367–367	378–465	398–488	455–555	335–410
North Carolina	311–381	385–483	311–381	—	352–436	385–483	275–345
Alabama	342–440	342–440	280–360	—	360–460	—	265–342
Michigan	418–525	418–525	362–451	404–496	418–525	433–532	412–475
Minnesota	370–450	370–450	400–487	370–450	385–468	433–526	370–450
Wisconsin	372–437	372–437	372–437	452–542	482–577	452–542	—
Colorado	410–528	—	330–420	—	381–488	475–620	355–455
Idaho	347–431	—	310–385	400–500	340–430	525–625	275–350
Washington	414–492	451–537	320–380	432–514	414–492	364–432	307–364
Oregon	360–460	420–525	326–400	400–500	440–550	360–460	360–420
Manitoba	365–540	365–540	305–580	350–440	290–365	380–540	250–320
Saskatchewan	337–409	337–409	—	300–364	479–585	364–442	308–328
Br. Columbia	355–440	385–515	280–330	330–390	420–500	330–390	340

[1] From "Pay Rates in the Public Service," published July 1958 by the Public Personnel Association, Chicago, Ill. (Pay rates show salary range for median-grade jobs requiring comparable training. They do not show the full spread of salaries for employees of all grades.)

their services, and so there does not exist this same stimulus to increase salaries. Such a circumstance is one over which the professionals in biology have little control and about which, it would seem, little can be done. At the same time, it might be considered that professions vary in difficulty and in their demands for special aptitudes. (We cannot all be, or at least do not choose to be, higher mathematicians or nuclear physicists.) Accordingly, some scientific workers are making more, partly because they are possessed of talents which set them apart—talents for which there is an acute demand and for which employers are openly competing.

In public service (essentially the only outlet for a fishery or wildlife biologist's services), it would appear that great variation exists in the rates of pay. However, job comparability between places of employment is something difficult to measure, and the broad differences in pay scales revealed in both surveys referred to here may be exaggerated for this reason. It is known, also, that job prerequisites vary appreciably and that this likewise reduces the dependability of pay-scale comparisons.

However, within any given state or unit of government, it may be assumed that so-called fringe benefits apply uniformly to all classes of employees, and a comparison of basic pay rates should be valid. From the table below, it would appear that pay rates of game biologists compare favorably with those of other workers having comparable training. In this connection, it should be evident, however, that while salaries of wildlife workers may be *comparable* to those of allied professions, this does not mean they are *adequate*. On the contrary, it is evident that pay levels of wildlife employees are woefully inadequate in many areas.

The committee was unable to conceive of any easy means for enlarging on the prestige and pay of workers in the field of resource management. It was generally felt that federal salary scales, averaging better than those in state government, serve as a pace-setter for most other employing agencies. In this connection a general pay raise in the Federal Civil Service during 1958 should have desirable effects on the profession generally.

The Fish and Wildlife Service attempted, through a study with the U.S. Department of Agriculture and the U.S. Civil Service Commission, to determine whether or not certain positions, including those of fish and wildlife biologists, were in shortage categories to permit increases in hiring rates. The study did not substantiate a case for such action. The Fish and Wildlife Service is also working with the U.S. Civil Service Commission on several other projects which should lead to added prestige and compensation for certain of the federal fisheries and game biologist positions.

It is evident that low pay is poor economy in any organization. It means employee dissatisfaction, a heavy rate of personnel turnover, and often leads to a staff of inferior ability. The consequence is a poor job, badly done and with a further impairment of public support. In this connection the committee recognized a considerable value in surveys of the Federation and Institute for pointing out major disparities in pay scales between states, and acknowledged the concerted efforts of the Sport Fishing Institute, the National Wildlife Federation, and the Wildlife Management Institute in calling to public attention the low level of salaries. It was felt that aggressive publicity, given to such information as was revealed by the surveys, offered one of the best means for aiding low-pay states to improve their salary levels.—Respectfully submitted, CHARLES H. CALLISON, LANSING A. PARKER, JOSEPH W. PENFOLD, DANIEL A. POOLE, A. HEATON UNDERHILL, NORMAN A. WILDER, AND J. P. LINDUSKA, Chairman.

Nominations

The briefest scanning of our Society roster by members of this committee, together with even the most casual knowledge of men listed thereon, posed a problem. It was evident that we had not to contend with a dearth of well-qualified nominees for the two offices to be filled; we faced the task of selecting a minimum number from a veritable host. As we weighed recognition of service rendered in the past, administrative ability and experience, potential service to the Society and conservation in general, and numerous other factors, there was a feeling that we could hardly go wrong.

Surprisingly, perhaps, a total of only eight prospective nominees were listed for the presidency and nine for the vice-presidency. Agreement on two nominees for each office came with a degree of committee unity that made our responsibility a seemingly light one in retrospect.

In one respect we interrupted tradition by nominating the incumbent president for election to a second consecutive term. This action was based jointly on a widespread respect and confidence in the individual involved, and a desire to afford Society membership an opportunity to demonstrate the feasibility of such a precedent should they wish. In no sense was that action intended as any question of or reflection on qualifications of either the other nominee or the many who might have been selected.

The committee's nominations were published in THE JOURNAL OF WILDLIFE MANAGEMENT (October 1958).—Respectfully submitted, WALLACE L. ANDERSON, F. S. BARKALOW, JR., E. L. CHEATUM, W. E. RICKER, AND W. C. GLAZENER, Chairman.

Professional Training

The Professional Training Committee was appointed about midyear and had to discuss, via correspondence, the principal functions which should receive its attention. The major activities of this committee have been directed toward: (1) arranging a program for the Wildlife Instructors' Meeting on Sunday night, March 1, 1959; and (2) assembling academic course requirements for the

TABLE 1.—ACADEMIC REQUIREMENTS FOR B.S. DEGREE IN WILDLIFE (GAME) MANAGEMENT, 1958

INSTITUTION	B.S. CONSIDERED PROFESSIONAL DEGREE	TOTAL QUART. HOURS REQUIRED	PERCENTAGE OF TOTAL QUARTER HOURS IN					
			Nat. Sci.	Biol. Sci.	Humanities	Wildl. Mgmt.	Other Required Courses	Electives
Alabama Poly.	No	211	21	36	10	2	18	13
Alaska	[1]	203	27	27	27	11	7	0
Arizona	No	187	16	32	33	10	5	5
British Columbia	No	[2]	32	50	17	2	0	0
Calif. (Berkeley)	[1]	180	17	23	33	9	8	10
Colorado State	[1]	220	19	21	10	27	16	7
Cornell	No	180	23	29	19	22	7	0
Florida Univ.	No	212	15	22	22	6	23	12
Idaho	[3]	226	24	15	17	7	18	19
Kansas State	Yes	192	17	21	14	16	9	22
Louisiana State	No	216	11	27	19	6	37[4]	0
Maine	[3]	219	10	29	10	11	26[4]	14
Massachusetts	[3]	180	15–23	11	18	18	10	12–17
Michigan State	Yes	192	17	33	19	5	9	17
Michigan Univ.	No	198	21	23	20	9	20	0
Minnesota	Yes	196	22	24	20	14	6	13
Missouri	No	192	11	24	13	13	15	25
Montana	Yes	204	26	29	12	15	13	5
Ohio	[3]	213	14	18	24	10	19	15
Oklahoma	[3]	183	12	32	19	6	0	31
Ontario Agric.	Yes	[2]	37	21	11	20	8	3
Oregon State	Yes	192	8	19	16	27	15	16
San Jose State	[3]	186	16	42	28	10	0	4
South Dakota	Yes	204	18	30	15	10	7	21
Southern Ill.	No	198	16	32	25	6	11	11
Syracuse	[3]	217	24	22	20	0	25[4]	9
Texas A & M	No	216	22	17	27	15	4	15
Utah State	Yes	198	20	22	12	14	5	27
Virginia Poly.	No	239	31	22	9	5	17[4]	16
Washington Univ.	[3]	206	28	30	15	10	10	7

[1] B.S. considered adequate by responding institution for general field appointment; not adequate for professional biologist.

[2] Canadian university credits not readily translatable to quarter-hour credits.

[3] This question not answered.

[4] Courses largely forestry, for forestry degree.

Bachelor's degree in game management from various educational institutions in North America.

The March 1 program consisted of (1) a panel discussion of what professional training is expected of wildlife graduates by wildlife administrators, (2) a presentation of results of the survey of the general academic requirements for the Bachelor's degree in game management at 29 institutions of North America, and (3) a discussion of the proposed publication of the techniques manuscript by The Wildlife Society.

A total of 30 institutions of higher learning supplied data on the course requirements for the Bachelor's degree in game management. Some of the results of this survey are shown in Table 1.

The current Professional Training Committee recommends that this committee be continued but that the objectives of this committee and those of the Employment and Job Standards Committees be more clearly delineated. The Professional Training Committee recommends that one of its major objectives be to determine minimum academic training standards expected of game-management graduates, both at the Bachelor's and Master's level.—Respectfully submitted, PAUL D. DALKE, RAYMOND F. DASMANN, JOSEPH J. HICKEY, HARRY D. RUHL, AND HENRY S. MOSBY, Chairman.

Wildlife Techniques

The Wildlife Techniques Committee completed, multilithed, and distributed for review about 100 copies of the techniques manuscript. The manuscript as distributed for critical comment included 17 sections, totaling about 439 pages (not including Appendix and Index). The total cost to the Society for the preparation, duplication, and distributing of this manuscript was $864.34. The reviewers, totaling more than 100 members of the Society scattered throughout North America, made a critical evalua-

tion of the techniques manuscript and their comments and suggestions for improvement were referred to the individual section authors. Revision of the manuscript, taking advantage of the reviewers' suggestions for improvement, is currently in progress.

The committee, at the request of Council, secured publication cost estimates from a commercial book printer, from the Wildlife Management Institute, and from a commercial offset printer. These estimates were forwarded to the Council with the recommendation that the manuscript be published at the lowest sale cost possible so that it might be of greatest use to various members of the wildlife profession. A large majority of the individuals who critically reviewed the manuscript recommended publication, and suggested periodic revision to keep the publication current.—Respectfully submitted, IAN MCT. COWAN, DAVID E. DAVIS, ANTOON DE VOS, ALEXANDER C. MARTIN, HORACE F. QUICK, RICHARD D. TABER, AND HENRY S. MOSBY, Chairman.

BRIEFER ARTICLES

THE HORNS AND TEETH AS INDICATORS OF AGE IN BISON

W. A. Fuller

Canadian Wildlife Service, Whitehorse, Yukon

This paper describes changes, associated with advancing age, in the form of the horns and in the eruption and subsequent wear of the teeth in the bison (*Bison bison*). The study was carried out in Wood Buffalo National Park, northern Alberta and southern Mackenzie District, N.W.T., and was part of a larger study of the biology and management of that animal. The material examined came from two sources. Sixty-five animals were either shot or found dead, mainly in the summer months. From this sample 26 jaws, representing a series of advancing age, were cleaned and preserved for permanent reference. Approximately 1,800 jaws were examined at the annual reduction slaughters, held in midwinter, in the years 1950 to 1955. Since a rather complete *post-mortem* inspection was carried out, only a short time was available for examination of the horns and teeth. For this reason, only jaws of unusual interest were preserved and the stage of tooth development or wear was entered on a specially prepared card by placing a check mark in the appropriate square. A brief description of the horns, often accompanied by a sketch, was entered on the same card.

Calves and yearlings can be recognized by body size, and therefore their approximate ages in months can be calculated. The study reported here suffers from a lack of older specimens of known age.

HORNS

The horns of males of various ages have been figured by several previous writers, notably Allen (1876), Hornaday (1889), and Garretson (1938). Seton (1929) has reproduced Hornaday's figure in part. Any one of these plates shows clearly how the horns, which project nearly laterally in the calves, gradually turn upward and finally inward. In mature animals the tips become blunted and shredded. According to Mohr (1949), this is caused by the new horns piercing through the old sheath. She reported that it occurs regularly at 4 years of age in the wisent (*Bison bonasus*), but the writer has found that it occurs later in American bison, probably at 7 or 8 years of age.

In using the horns for aging male bison in the field, it was found impractical to attempt to distinguish between 2- and 3-year-olds except under the most favorable conditions. Both were therefore lumped under the designation "spike-horn." It was also difficult to differentiate in all cases between a spike-horn and a young adult—the 3- and 4-year-olds of Seton's plate (*op. cit.*, p. 665). It was relatively easy to spot the stepped horn tips of the mature and aged animals, and also to identify calves and yearlings where general body size affords an important clue. Thus, it is practical to set up five age-classes that are recognizable in the field, as follows:

calf—less than 1 year
yearling—1 to 2 years
spike-horn—2-, 3- and some 4-year-olds
young adult—4 years to ? (7 or 8 years)
adult and aged—more than 7 or 8 years.

The horn of the female has not been described in comparable detail. It differs from that of the male in several respects. First, there is practically no spike-horn stage. By the third winter, the inward curve has been attained. Second, there is a pronounced posterior deflection of the tips, so that the mature horn curves inward and backward. Third, there is no continued enlargement of the basal diameter. Fourth, after the full curvature has been attained in early maturity, the basal part of the horn grows straight away from the head, thus carrying

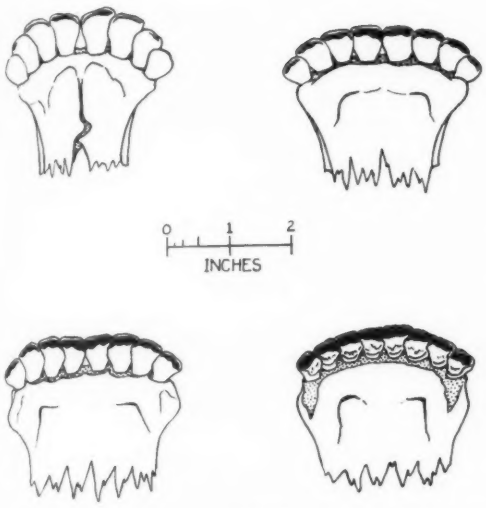

FIG. 1. Stages of wear on incisiform teeth of bison. At the upper left is a 3-year-old, showing slight wear on the incisors and no wear on the canine. At the upper right is a late 4-year-old, showing the beginning of wear on the canine. The lower left depicts the "adult" condition with moderate wear on the canine, and the lower right, the "aged" condition, showing heavy wear on all the occlusal surfaces and "necks" below the crown.

the curved portion farther laterally with each succeeding year. Fifth, there is seldom any fraying of the horn tips. Sixth, there is quite commonly a fracture of the entire horn 5 or 6 in. from the base, which results in loss of the entire curved portion and retention of a mere stub about as long as the bony core. This seems to be a result of the form of development described above.

From the practical viewpoint of using the horns as criteria of age, it is difficult to recognize any female counterpart of the spike-horn group in males. This is not too serious, because about one-third of the cows attain sexual maturity at 2 years of age, and most of the others, probably, as 3-year-olds. There is little need, therefore, to recognize a subadult, nonbreeding age group.

Aged cows are recognized by the long, straight basal portion of the horns, or by the presence of "stubby" horns on one or both sides.

Annual growth rings are too difficult to detect to be of much value as age indicators. I made a study of aging by both horn rings and dental characters during the November–December 1952 slaughter. Horn rings gave too low a value for yearlings and 2-year-olds, and too high a value for 4-year-olds and older. Horn rings were not discernible on many animals classed as 3-year-olds by dental characters. False annuli, being indistinguishable from true growth rings, appear to be common in older specimens and were therefore discarded in favor of dental characters for all subsequent age determinations on slaughtered animals.

DENTITION

The teeth of the bison are similar to those of the domestic milk cow, not only in dental formula but also in the form of the individual teeth, and the time and manner of replacement. The dental formula is: $I\frac{0}{3}, C\frac{0}{1}, P\frac{3}{3}, M\frac{3}{3} = 32$. The lower canine is incisiform and is often called (incorrectly) the fourth or "corner" incisor. The most anterior premolar (P_2) has a relatively simple architecture, whereas P_3 and P_4 are progressively more complex and molariform. The premolars and molars are selenodont to a marked degree. On each molar, between the anterior and posterior cusps, there is a style which is found on the lingual side in the upper jaw, and on the labial side in the lower jaw (Fig. 2). The occasional anomalous development of the first premolar has been described by Fuller (1954).

The normal sequence of eruption of the deciduous and permanent dentition, and subsequent stages of wear, has been worked out and applied as a means of aging carcasses at the annual slaughters in Wood Buffalo National Park. The description of these processes that follows is based on the lower jaw, but the replacement sequence is pretty well synchronized between upper and lower teeth.

At birth the complete deciduous dentition is present, but is covered by a thin, semitransparent membrane that is sloughed off in the first few days of life. The next major change occurs at about 3 months when the anterior cusp of the first molar (M_1) pierces the gum. The posterior cusps do not emerge fully until sometime between the ninth and twelfth months. During the second year, the second

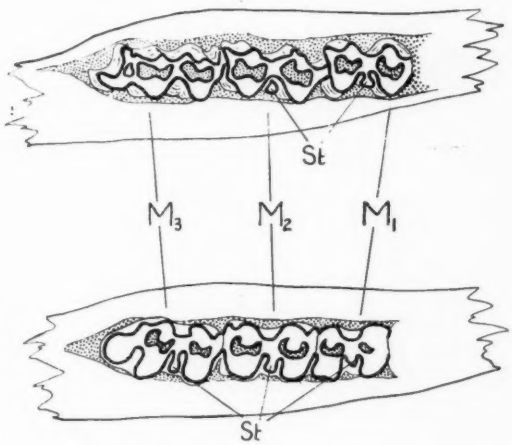

FIG. 2. Stages of wear on molar teeth of bison. The upper drawing depicts a 4-year-old. The style (St) on the first molar (M_1) is worn to a loop; on the second molar (M_2), it is worn to a circle; and it is not yet in wear on the third molar (M_3). The lower drawing represents the appearance of the molars in old age with all styles worn to loops.

molar (M_2) appears and, like M_1, requires several months for its complete eruption. In the third year, several important changes occur. The two central pairs of incisors (I_1 and $_2$) are shed and replaced; deciduous premolars two and three (dP_2 and dP_3) are likewise replaced; and the third molar (M_3) erupts. The deciduous fourth premolar (dP_4) usually is retained longer than dP_2 and dP_3, but occasionally it is shed before the others. The premolars in general are more erratic than the incisors in their development and consequently are not reliable as indicators of age. M_3 in bison, as in many other ruminants, possesses a rudimentary third cusp which does not come into wear for some months after the two main cusps. A "full mouth" or complete set of permanent teeth is acquired during the fourth year when dI_3 and dC_1 are shed and replaced and the third cusp of M_3 comes into wear. From this point on, age must be judged by the amount of wear on the teeth and, consequently, aging becomes less precise.

By the time the full mouth is acquired, there is a thin line of wear apparent on I_1 to I_3 (Fig. 1, upper left) and the style of M_1, which is at or below the gum line when the tooth first erupts, is in wear. At first, only the free tip of the style wears away, producing a circular enamel pattern on the occlusal surface (Fig. 2, upper, M_2). As the tooth is progressively worn away, the enamel pattern of the style becomes a loop (Fig. 2, upper, M_1). In the fifth year, a slight amount of wear appears on the canine, and progressively more wear appears on the incisors, particularly I_1 (Fig. 1, upper right). The style on M_1 always shows a loop, the style on M_2 is usually a circle or occasionally a loop, while the style on M_3 is not yet in position to wear (Fig. 2, upper).

I did not attempt to recognize individual year classes for animals older than 4 years. However, three additional groups were defined with considerable precision. "Young adults" have the style on M_3 worn to a circle (never a loop), but still show only slight wear on the canine. The limit for slight wear is arbitrarily defined as 2 mm. By this time, the worn area on the incisors is approaching 4 mm., and is classed as moderate. In the "adult" group the wear on one, two, or three incisors may exceed 4 mm., whereas on the canine it is between 2 mm. and 4 mm. in width (Fig. 1, lower left). The styles on M_1 and M_2 usually show loops, whereas the style on M_3 is typically still in the circle stage. When wear on C_1 exceeds 4 mm. (Fig. 1, lower right) and the style on M_3 wears to a loop (Fig. 2, lower), the animals are classed as "aged."

It will only be possible to assign a numerical age to these last three classes when known-aged animals become available. In the meantime it is my thought that the young adult group contains mostly 5- and 6-year-olds, and that the division between adults and aged probably comes at about 12 or 15 years of age. A good correlation has been observed between the appearance of a shoulder on the horn tips and the development of the dental characteristics associated with the adult category.

To make these criteria more useful as a practical means of age determination, the following dichotomous key has been constructed.

1. Deciduous teeth all present.
   2. Second molar absent.
      3. First molar not visible ..... 0–3 mo.
      3. First molar erupting to fully grown ..... 3–12 mo.
   2. Second molar erupting to fully grown ..... 1 yr.
1. At least central I's permanent.
   4. C_1 deciduous or shed, never permanent; I_{2-3} deciduous or permanent.
      5. I_3 deciduous; I_2 deciduous or permanent; 3rd cusp of M_3 not in wear; style on M_1 just commencing to wear, or worn to circle (rarely a loop) ..... 2 yr.
      5. I_3 permanent; C_1 deciduous or shed; style on M_1 typically a loop; occasionally circle or not worn ..... (in part) 3 yr.
   4. All teeth, including C_1, permanent.
      6. No visible wear on C_1; style of M_3 not in wear.
         7. Typically no wear on I_3 as well as C_1; style of M_2 not in wear or with wear on tip only ..... (in part) 3 yr.
         7. Typically slight wear on I_3; style of M_2 usually a circle. Occasionally slight wear on C_1 if style of M_2 not in wear ..... 4 yr.
      6. Visible wear on C_1.
         8. Wear on C_1 not exceeding 2 mm.; M_2 style circle or loop; M_3 style not in wear or tip only worn ..... young adult
         8. Wear on C_1 exceeding 2 mm.
            9. Wear on C_1 2–4 mm.; M_3 style rarely a loop ..... adult
            9. Wear on C_1 more than 4 mm.; M_3 style usually a loop ..... aged

SUMMARY

Five age classes of male bison and four age classes of female bison can be recognized in the field on the basis of horn growth. Tooth eruption and replacement permit the recognition of five age classes separated by 1 year (0–4 years inclusive). Tooth wear permits recognition of an additional three age classes, designated "young adult," "adult," and "aged," which cover the remainder of the life span of the animals.

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BRUCELLOSIS AND LEPTOSPIROSIS IN WHITE-TAILED DEER IN MICHIGAN

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The question of the occurrence of brucellosis in wild deer is of concern to game managers, livestock people, and disease-eradication agencies alike. The game manager is concerned about the direct effects the disease may have on the deer themselves, and the conflicts that might develop between wildlife and livesock interests if deer should be reservoirs for the disease. Cattle owners often suspect that deer are disseminators of brucellosis. State and federal disease-control workers are concerned because, if the disease should be prevalent among deer, it would complicate their program for eliminating brucellosis in cattle.

From 1947 to 1956, the Michigan Department of Conservation made occasional collections of blood from deer killed by hunters and from captive wild deer (*Odocoileus virginianus*) held for experimental work. The Department of Agriculture Brucellosis Testing Laboratory located at Michigan State University tested 55 such samples for brucellosis. All were negative.

During the 1957 deer-hunting season (November 15–December 2) the Michigan Department of Conservation with the co-operation of the U.S. and Michigan Departments of Agriculture carried out an extensive program for screening deer serum for brucellosis. In addition, after the hunting season in 1957 and early in 1958, Conservation Department personnel collected blood samples from deer killed by automobiles and sent them to the Game Division Laboratory for testing. Because of the current interest in leptospirosis in domestic and wild animals, we decided to extend the program to include testing serum for leptospirosis.

The bulk of the blood samples were collected in individual vials by Conservation Department biologists at various deer-checking stations. Samples collected at these stations were transported to one site, the Standish deer-checking station, where we made the brucellosis tests in a Department of Agriculture mobile laboratory. To extend the program, we distributed approximately 200 vials in mailing tubes to hunters and Conservation Department personnel, instructing them to mail samples of blood to the Standish station. The mailed samples proved to be generally unsatisfactory, as most of them had hemolyzed by the time we received them for testing.

The deer examined at checking stations were already eviscerated by the hunters, but in most cases a small pool of blood in the body cavities provided satisfactory samples. Frequently, the blood was mixed with digestive-tract fluids and other extraneous matter. The samples obviously contaminated

FIG. 1. Distribution of deer tested for brucellosis.

FIG. 2. Deer-population density. Light to heavy deer population indicated by light to dark shading.

TABLE 1.—RESULTS OF TESTS FOR BRUCELLOSIS AND LEPTOSPIROSIS IN MICHIGAN DEER, NOVEMBER 15, 1957 TO JUNE 1, 1958

DEER		NUMBER OF SAMPLES TESTED FOR LEPTOSPIROSIS						NUMBER OF SAMPLES TESTED FOR BRUCELLOSIS[1]
Sex	Age in Years	No. Tested	Negative	Positive at Serum Dilutions				
				1:100	1:1,000	1:5,000	1:10,000	
MALE	½	12	12					51
	1½	34	29	2		3		165
	2½	16	12	1	2	1		53
	3½	6	5	1				39
	4½	2	1			1		4
	5½							1
	6½							1
	"Adult"	1		1				3
	Unknown	30	23	3	2	2		198
	Subtotal	101	82	8	4	7		515
FEMALE	½	17	13	3		1		69
	1½	10	8	2				40
	2½	11	6	2	3			29
	3½	8	7				1	34
	4½	4	2	1			1	17
	5½	2	1		1			13
	6½	1		1				4
	7½	1	1					6
	8½	1	1					8
	9½							2
	10+	1	1					4
	"Adult"	20	10	3	4	2	1	30
	Unknown	13	8	2	3			94
	Subtotal	89	58	14	11	3	3	350
Sex and age unknown								1
Totals both sexes		190	140	22	15	10	3	866

[1] All negative for *Brucella abortus*; 190 of these samples tested for leptospirosis.

with foreign material were discarded. No samples were taken when temperatures were below freezing, frozen blood being unsatisfactory for diagnosis in this study.

BRUCELLOSIS

Of the samples collected during and following the 1957 deer-hunting season, 866 from 55 counties (Fig. 1) were satisfactory for testing by the brucellosis plate-agglutination method. The antigen used was prepared from *Brucella abortus* strain 1119-3 supplied by the U.S.D.A. All of the 866 samples were tested at the 1:25 dilution, and over 500 of these were tested in four dilutions. All were negative for brucellosis. Current experiments at the Game Division Laboratory with artificially infected deer show that deer will develop antibody titers as high as 1:6400 and hold a high titer for at least 9 months.

Our sample included deer of all ages and both sexes (Table 1). The distribution and number of samples correspond favorably with the distribution and population densities of the deer in the Lower Peninsula (Figs. 1 and 2). The northern part of the Lower Peninsula of Michigan, where we took most of the samples, is mostly forested land interspersed with farming communities. This region supports a large deer population, estimated to be as high as 30–40 deer per sq. mile in its most heavily populated areas. Since many of the farms keep cattle that graze in fields adjoining or extending into wild land, there is considerable overlap of range and opportunity for deer–cattle contact and exposure. The distribution of cattle in the state and the current incidence of brucellosis in this population (Fig. 3) show that deer have ample opportunity to occupy areas having infected cattle. The incidence of brucellosis in cattle is low, due to the brucellosis-eradication program of the Department of Agriculture. The incidence in cattle from 1946 to 1954 was four times greater than at present, affording even more opportunity for deer exposure. It seems to us that, if brucellosis were to become endemic in the deer herd, it would be present now. In view of the completely negative findings of brucellosis in deer of any age, and the presence of the infection in cattle both past and present, the deer herd can apparently be ruled out as a carrier or reservoir of the disease in Michigan.

There is increasing evidence that white-tailed deer may be unimportant in the spread of brucellosis. Steen, *et al.* (1955) made a thorough

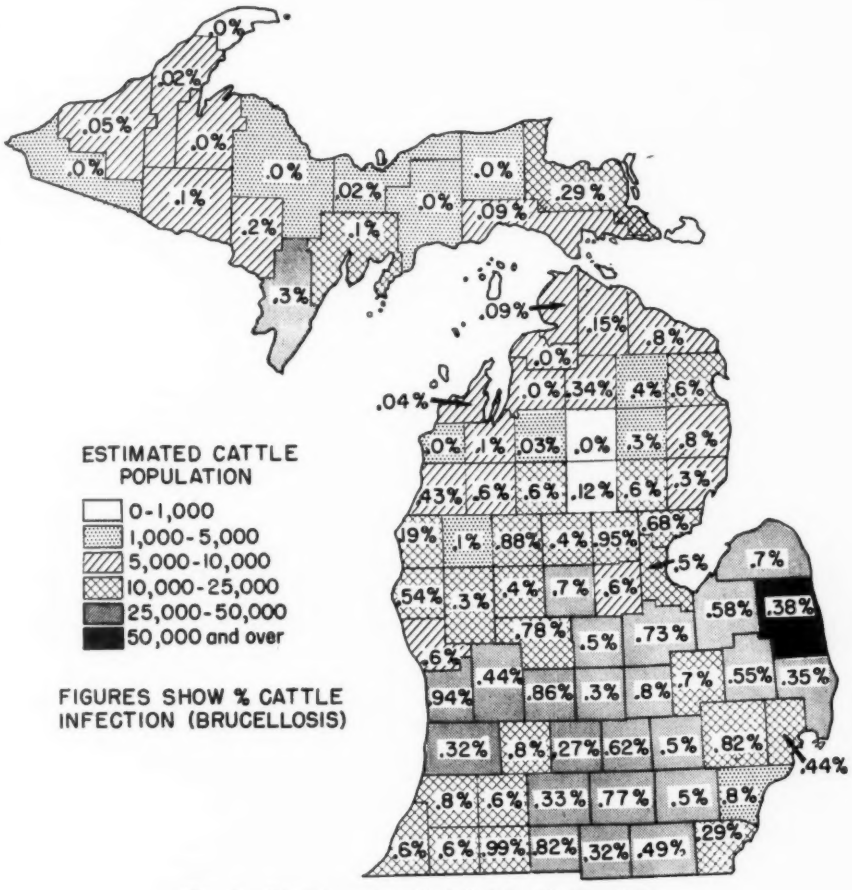

FIG. 3. Percentage of cattle infected with brucellosis.

review of the literature. They cite negative findings in Ohio and Minnesota. In three North Dakota groups, there was one reactor among 436 tested, one among 4, and none among 70. Steen, *et al.* (*ibid.*) found no evidence of brucellosis among 996 Missouri white-tailed deer. Wedman and Driver (1957) found only one reactor among 179 samples from deer in Minnesota. Reynolds and Smith (1958) found no reactors in over 400 deer in Massachusetts. The Southeastern Cooperative Deer Disease Study (1958) found one reactor in 403 samples from ten southeastern states.

LEPTOSPIROSIS

The agglutination–lysis test for leptospirosis, described by Schüffner and Mochtar (1927), was conducted at Michigan State University by the Diagnostic Bacteriology Service of the School of Microbiology. Of the 866 samples collected, 190 were suitable for this test. Bacterial contamination and hemolysis rendered many samples unfit for diagnostic tests.

Leptospira pomona antigen was used on all of the 190 samples. In addition, 40 of these were tested against *L. canicola* and *L. icterohaemorrhagiae* antigens. None of the serums had antibodies against *L. canicola* or *L. icterohaemorrhagiae* antigens. Of the samples tested with *L. pomona* antigen, 50 were positive or suspect, and 140 were negative. The significance of the titers, which ranged from 1:100 to 1:10,000 (Table 1), is undetermined. None of the serums showing *L. pomona* titers could be correlated with the sex, age, or location of the deer. Deer reacting to the test were widespread geographically (Fig. 4).

The incidence of leptospirosis in wild and domestic species in Michigan is not known. Herd outbreaks of active infection in cattle do occur, and titers have been discovered in herds where no clinical symptoms are known to have occurred, indicating the disease may be widespread and prevalent in cattle. In Georgia, McKeever, *et al.* (1957) isolated *L. pomona* from the striped skunk, raccoon, and wildcat; several additional serotypes were isolated from these and other wild species. No findings

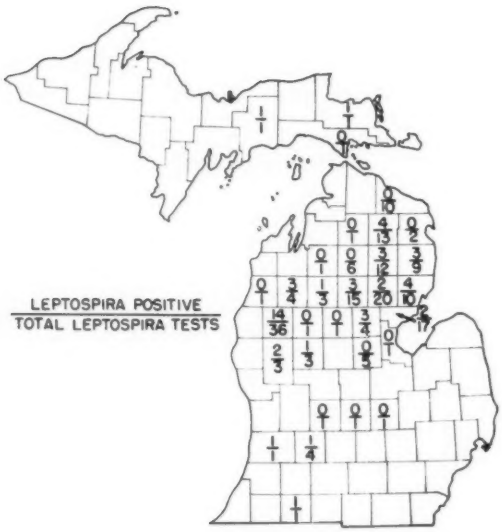

FIG. 4. Distribution and results of leptospirosis tests on deer.

have been reported from wild animals in Michigan. The role of wild animals in the epizootiology of leptospirosis should be investigated further.

SUMMARY

Michigan deer are apparently free of brucellosis. All of the *Brucella abortus* plate-agglutination tests on 866 deer-serum samples at the 1:25 dilution were negative. *Leptospira pomona* agglutination-lysis tests were made on 190 samples: Titers were found in 50; 140 were negative. In addition, 40 of these samples tested with *L. canicola* and *L. icterohaemorrhagiae* antigens were negative. There was no correlation as to location, sex, or age of the deer that showed *L. pomona* titers.

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ADDITIONAL USES OF DYES FOR STUDYING THE MOVEMENTS OF SMALL MAMMALS

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In a previous paper (New, 1958), I reported on the use of water-soluble dyes for marking the scats of small mammals in order to gather data on their movements. This paper reports on experiments testing water-soluble and fat-soluble dyes which, when mixed with bait, may be used to mark the fat, teeth and pelage of small mammals during the course of movement studies.

The method of testing water-soluble dyes in the field and a list of recommended dyes was given in New (1956, 1958).

The author is indebted to W. Robert Eadie for his encouragement and advice and to the New York State Science Service which helped to support the field work. Kile R. Barbehenn offered many valuable suggestions for which I am grateful.

METHODS AND PROCEDURES

Water-soluble and fat-soluble dyes were tested in the field by placing each dye at specific stations in a grid, at all stations in certain lines, or by using a different colored dye in each line of a grid and then repeating the sequence so that every station in the grid had dyed bait. The water-soluble dyes used were those recommended in New (1958). Data were collected by placing snap-traps in all the bait boxes or at specific stations, thus trapping the mammal population at intervals after the dyed bait was removed. The pattern of distribution of the snap-traps was determined by the pattern of dyed-bait placement. Reference to New (1956) will provide detailed information. Snap-trapped mam-

mals were placed in coin envelopes as they were removed from the trap. The envelope was marked with the location of the trap in the grid, and any information on dyes obviously present was noted while in the field. In the laboratory the animals were examined externally and internally with visible and ultraviolet light. A dissecting microscope was used to detect the presence of dyes not distinctly visible to the unaided eye.

Data regarding the number of stations visited by individual animals were obtained by placing galvanized, ¼-inch wire-mesh, single-catch-type live-traps at selected stations in the grid. The water-soluble dyes recommended in New (1958) were mixed with Ken-L Ration dog food, and this bait was then placed in the live-traps to catch short-tailed shrews (*Blarina brevicauda*). Oat flakes mixed with water-soluble dyes were used to live-trap white-footed mice (*Peromyscus leucopus*) and meadow mice (*Microtus pennsylvanicus*). The method of mixing the dye with the bait is described in New (1956, 1958).

In order to mark live-trapped shrews and white-footed mice, these animals were first brought into the laboratory, fed dyed bait during the day, and released late in the afternoon at the capture station. This technique did not work with *Blarina* but was successful with *Peromyscus*. Bringing animals into the laboratory was therefore abandoned, and the dyed bait was placed in the trap in the field. Captured animals were then released after they had been given what seemed sufficient time to ingest enough dyed bait. Live-traps set for shrews were always visited within 4 hours after setting, to reduce mortality. This technique worked well with *Blarina* but not with *Microtus* or *Peromyscus*. The recovery of dyed scats at stations in the grid around the live-trap gave some indication of the number of stations visited by an individual and the distances moved from the point of capture.

The area to be live-trapped was divided into four quadrants, and four live-traps were placed in each quadrant. The four traps had four different dyes, and the same color dye in different quadrants was kept sufficiently distant to prevent overlap in movements should two animals be caught and marked with the same dye. Traps within the quadrant were placed at active shrew or mouse stations with the intention of capturing four animals within the same trapping period. This was never accomplished, although the maximum caught in one quadrant was three shrews. Only two individuals had eaten sufficient dye to indicate their movements. If only one animal was caught in a quadrant, the other three traps were removed to prevent this individual from entering the other traps and eating a different dye. This reduced greatly the number of animals that could be marked. The type of trap used created other problems because the door would sometimes fail to lock, thus releasing one animal and allowing another to gain entrance to the same dye. After a period of live-trapping, the area was not trapped again for 24 hours in order to allow the dye to pass through the marked animals.

Fat-soluble dyes were mixed with peanut butter or oat flakes. The animals were snap-trapped, and the fat was examined for staining. Although Eadie (unpublished) successfully used sudan III to mark the fat of *Microtus*, fat-soluble dyes were not tested in this study with the meadow mouse. In several experiments two dyes were mixed together. In one instance 18 gm. of alizarin and 6 gm. of sudan black were mixed with 9 lb. of oat flakes. In another trial, 20 gm. of alizarin were mixed with 5 gm. of sudan III and 400 gm. of peanut butter.

All dyes tested in the field were previously tested in the laboratory with white mice or white rats. Some dyes were also tested in the laboratory with white-footed mice and meadow mice.

RESULTS

Laboratory Tests of Dyes

Pelage-marking dyes.—Many water-soluble and fat-soluble dyes remained on the pelage of laboratory-tested animals for a few days after dyed bait was removed. The water-soluble dyes recommended in New (1958) were found to mark the pelage in laboratory tests and were then used in field tests.

Tooth-marking dyes.—Alizarin red S, phloxine, rose bengal, fast green FCF, and hematoxylin were found to color the dentine surfaces of the incisors and molar teeth in *Microtus*. Dry, dyed food was found within the re-entrant angles of the molars. Hematoxylin and alizarin marked the dentine surfaces of the incisors and the molar surface in white mice and rats. Only hematoxylin colored the teeth of *Peromyscus* in this way. *Blarina* teeth were unmarked by any dyes. Alizarin remained on the teeth of one white rat 26 days after the dyed food was removed.

Fat-marking dyes.—Sudan III was found to stain the fat of *Peromyscus leucopus* an intense salmon-orange to red color. The color remained intense for 2 weeks after feeding. Sudan III and IV were ineffective with white mice and rats. Sudan black stained the fat a blue-black color and was effective with white mice, white rats, *Microtus*, and *Peromyscus*.

Field Tests of Dyes

Pelage-marking dyes.—No dyes were found that would mark the pelage or external parts for long periods of time. The water-soluble dyes are lost very quickly, especially in *Blarina*. They are retained longer on *Peromyscus* because of the less fossorial habits and long tail. When several colors were present on a white-footed mouse, at least two or three were on the tail. Dye-marked white-footed mice were taken up to 36 hours after bait removal. Some *Peromyscus* still retained the dye in the intestine at this time, but usually only the pelage was marked. Dye was seldom found internally in shrews more than 12 hours after bait removal, probably as a result of the high rate of metabolism in these

animals. Externally, the dye was lost within 24 hours.

When dyes had been placed at all stations in the grid and then the whole area was snap-trapped following the removal of dyed bait, it was found that 111 of 240 *Blarina*, 36 of 42 *Peromyscus*, and 40 of 77 *Microtus* were marked with dyes. In most instances the dye was on the paws, lips, or pelage. No shrews were marked with more than two dyes, and 93 were marked with only one dye. Among the white-footed mice, 1 animal was marked with four dyes, 5 with three, 11 with two, and the rest with one.

Tooth-marking dyes.—Alizarin red S was used successfully in marking the teeth of *Microtus* for up to 5 days after dyed bait removal. The dye apparently coated only the dentine surfaces of the molar and incisor teeth. No enamel appeared colored. The molariform teeth were colored over the surface and in the loops and triangles. In cricetid teeth of *Peromyscus*, the dye appeared to adhere to the surface layer. White-footed mice were recovered with marked teeth up to 9 days after dyed bait was removed. Alizarin was used in both oat flakes and peanut butter. Preference for bait when mixed with alizarin was not determined. Neither bait was accepted avidly when mixed with this dye. Possibly the concentration of dye used was too great. In both trials where this dye was used, especially for *Peromyscus*, other dyes were mixed in the bait with the alizarin, as indicated under methods.

Hematoxylin was unsuccessfully used to mark the teeth of meadow mice, white-footed mice, or shrews under field conditions, although it was effective as a water-soluble dye to color the feces of shrews. Some *Microtus* were taken with hematoxylin-marked teeth, but all were captured at the station where the dye was originally placed and within 2 days of bait removal. This was also true for the other dyes used.

No white-footed mice were marked with sudan black, although seven mice were recovered with alizarin-marked teeth. Neither alizarin nor sudan black produced any marking of shrews in the field. These dyes were not tested in the laboratory with *Blarina*. The dyes were both evident visually in the bait when used, although only 2 gm. of sudan black per 3-lb. box of oat flakes may be inadequate. This dye was not tested further.

Fat-marking dyes.—Fat staining with sudan III occurred in *Blarina* and *Peromyscus*. The dye was not tested with *Microtus*. Only some of the attempts to mark shrews and white-footed mice with sudan III were successful, but no explanation for unsuccessful attempts can be given. The normal color of fat in shrews varies within the individual and among individuals. It is most often a delicate pink shading toward white, but fat other than mammary tissue was found sometimes to be quite pink. In one experiment a bait mixture of alizarin, sudan III, and peanut butter was placed at selected stations and left for 3 days. Three days later one white-footed mouse and one shrew were taken with intensely stained fat. The color was a vivid salmon-orange, almost red, and quite unmistakable. Shrews with sudan III stained fat were recovered up to 10 days after the bait was removed. A total of five shrews were captured 8 days and one, 1 day after bait removal. Fat was usually stained in the shoulder region, along the back, and abdominally. Fat surrounding internal organs, and in males especially around the testes, was stained intensely. *Peromyscus* was recovered with sudan III stained fat up to 3 days after bait removal. Sudan black was ineffective with shrews, meadow mice or white-footed mice when used in the field.

Live-trapping.—Distances moved by dye-marked live-trapped mammals were similar to those recorded in the snap-trapping and scat recovery (not involving live-trapping) portions of this work. The data are similar to those reported in New (1958). As reported in that paper, it was found that *Blarina* moved greater distances in the field than they did in the woods. Although the live-trapping technique worked with *Blarina*, *Peromyscus* and *Microtus*, best results were achieved working with shrews.

The number of stations visited by dye-marked shrews released from live-traps is enclosed in parentheses, preceded by the number of individuals visiting that number of stations. In the woodlot the data are: 5(1), 1(2). In the field the data are: 4(1), 3(2), 1(3), 1(4), 1(5), 1 (6), and 1(8). Rough estimates of the areas involved for the shrews in the field that visited 4, 5, 6, and 8 stations are, respectively: 0.3, 0.3, 1.0 and 0.5 acre.

The first white-footed mice live-trapped were brought back to the laboratory and allowed to feed on dyed bait during the day while in the trap. One mouse was released on the evening of the day it was captured, and on the following morning colored scats were recovered at four stations. This animal was released at the station at which it was caught and moved over a minimum area of 0.2 acre during the night. A second mouse treated the same way covered an area of 0.5 acre during two nights. Two scats were recovered the day after this mouse was released and a third scat the second day after release.

DISCUSSION

Further work with fat-soluble dyes seems warranted. Problems requiring further attention involve the correct proportions of dye and bait, the most suitable type of bait, and the factors involved in duration of staining. Shrews were not marked with sudan black. Perhaps the amount of dye used in this study was too small. Shrews took oat flakes avidly, but white-footed mice were not as attracted. Possibly the peanut butter with its high oil content is a better vehicle for sudan III than oat flakes. The dye and the oil may be absorbed together in some way not achieved when the bait is oat flakes. There may be a difference in time of passage of oat flakes and peanut butter through the alimentary tract. Peanut butter may pass through more slowly, thus

allowing more time for dye absorption. Fat utilization may determine the length of dye retention.

The live-trapping technique used in this study was partially successful and suggested several aspects requiring modification. Shrews are readily captured and, if the traps are attended frequently, mortality can be minimized. When the shrews first enter the trap, they will feed on the dyed bait if not disturbed. Apparently shrews cease to feed once they become disturbed; and, consequently, nothing is accomplished by keeping them captive. The development of a different type of live-trap could solve this problem. If the trap was designed so as to release the animal but not permit re-entry, much time would be saved. Confining the bait to the trap was also a problem because the trap used was made of wire mesh. Every effort should be made to prevent the scattering of dyed bait. Because of their consistency, canned dog food and peanut butter are desirable baits. Further work with white-footed mice and the live-trapping technique described is warranted, even though the results in this study were poor. The sample that I worked with was rather small. A suggested variation in the live-trapping technique might work quite well with white-footed mice. Different dyes could be placed at certain stations in a small area. After a period of exposure to the bait, subsequent live-trapping and close examination of the captured animal might reveal a number of dyes on the individual. From the dyes present, the investigator can determine the area traversed and the distances moved by the captive. If the mouse is then toe-clipped for future reference and the procedure continued by placing dyes at a different set of stations, recapture of the same animal will reveal more information regarding its home range. Since each capture may reveal two or three data, the home range can be determined more rapidly than with the standard technique which does not use dyes. A dye not used at any station also can be included with the bait in the trap. Recovery of dyed scats will supply additional information on movements.

Summary

No dyes were found that would mark the pelage or external parts of mice and shrews for extended periods of time when mixed with bait. Alizarin red S was successfully used to mark the teeth of meadow mice up to 5 days after bait removal, and white-footed mice up to 9 days after bait removal. The teeth of short-tailed shrews were not marked with alizarin. Sudan III was recovered in the fat of snap-trapped white-footed mice 3 days, and in short-tailed shrews 10 days, after bait removal. In the laboratory one white-footed mouse retained sudan III for 2 weeks after it was fed the dye. No other dyes used to mark teeth or fat were successful in the field. Sudan black strikingly marked the fat of white mice and white rats.

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MOURNING DOVE FOODS IN FLORIDA DURING OCTOBER AND DECEMBER

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Mourning doves (*Zenaidura macroura*) occur abundantly in Florida as a resident spring and summer breeding population, and in still larger numbers as a fall and winter migrant population. They have received considerable recent attention through the efforts of the Cooperative Dove Study initiated in 1948. This co-ordinated project has resulted in numerous publications, two of which concern the mourning dove in Florida, namely Winston (1954) and the Southeastern Association of Game and Fish Commissioners (1957). Both of these investigations, however, were concerned chiefly with population variations, migratory movements, and hunting data. The present paper attempts to supplement these studies by reporting briefly on the food habits of mourning doves in Florida. An earlier report of Florida dove foods was based upon only four crop analyses (Knappen, 1938).

Crops examined consisted of a total of 137 collected as part of Federal Aid Projects W-22-R and W-41-R by Florida Game and Fresh Water Fish Commission personnel in southeastern Florida (e.g., Dade County) during October 1950, 90 October crops collected by the author and his associates in north-central Florida (e.g., Alachua County) from 1952 through 1954, and 50 December crops simi-

[1] Assistance in identifying plant material was given by Alexander C. Martin, U.S. Bureau of Sport Fisheries and Wildlife, and by Albert M. Laessle, Department of Biology, University of Florida. Lawrence A. Hetrick, University of Florida Department of Entomology, assisted in naming much of the insect matter. Student assistants of the School of Forestry aided in the separation and weighing of the various food items.

TABLE 1.—PRINCIPAL FOODS OF THE MOURNING DOVE DURING OCTOBER IN SOUTHEASTERN FLORIDA AND DURING OCTOBER AND DECEMBER IN NORTH-CENTRAL FLORIDA

FOOD ITEM	SOUTHEASTERN FLORIDA		NORTH-CENTRAL FLORIDA			
	October (137)[1]		October (90)		December (50)	
	Amt.	Occ.	Amt.	Occ.	Amt.	Occ.
PLANT SPECIES[2]						
Pricklepoppy (*Argemone* spp.)	42.0[3]	44	0	0	0	0
Ragweed (*Ambrosia elatior*)	36.0	86	1.0	14	4.9	42
Croton (*Croton* sp.)	13.2	21	4.7	38	0.2	12
Paspalum grass (*Paspalum* sp.)	3.1	50	1.2	42	0.2	12
Knotroot bristlegrass (*Setaria geniculata*)	1.6	7	5.3	49	0.4	8
Common pokeweed (*Phytolacca americana*)	1.4	7	2.7	20	0.1	6
Carpetgrass (*Axonopus* spp.)	1.1	4	T[4]	1	0	0
Corn (*Zea mays*)	0.6	4	39.8	44	43.0	64
Barestem paspalum (*Paspalum longepedunculatum*)	0.4	5	0	0	0	0
Sorghum (*Holcus sorghum*)	0.2	1	0	0	0	0
Oats (*Avena sativa*)	0.1	1	0	0	T	2
Aneilema nudiflorum	0.1	1	0	0	0	0
Sesbania (*Sesban* sp.)	0.1	1	0	0	T	2
Hairy crabgrass (*Digitaria sanguinalis*)	T	2	0.5	27	T	12
Panic grass (*Panicum* sp.)	T	11	1.0	21	0.1	6
Wheat (*Triticum aestivum*)	T	3	0.8	2	0	0
Flatsedge (*Cyperus* sp.)	T	7	0.7	17	0.1	14
Partridgepea (*Chamaecrista* sp.)	T	1	0.3	3	0.1	4
Noseburn (*Tragia* sp.)	T	1	0.1	6	0	0
Mexicanclover (*Richardia scabra*)	T	3	0.1	17	0.3	8
Peanut (*Arachis hypogaea*)	0	0	40.3	60	49.7	64
Treadsoftly (*Bivonea stimulosa*)	0	0	1.0	4	T	2
Bristlegrass (*Setaria* sp.)	0	0	0.1	1	0	0
Passion flower (*Passiflora incarnata*)	0	0	0.1	2	0	0
Buttonweed (*Diodella teres*)	0	0	0.1	3	0.1	2
Watermelon (*Citrullus citrullus*)	0	0	0.1	1	0	0
Starglory (*Quamoclit quamoclit*)	0	0	0	0	0.4	6
Herculesclub (*Zanthoxylum clava-herculis*)	0	0	0	0	0.1	2
Totals	99.9	–	99.9	–	99.7	–
ANIMAL MATTER						
Gastropoda (snail shells)	T	3	T	1	0	0
Isopoda (sow bugs)	T	1	0	0	0	0
Orthoptera (grasshopper eggs)	0	0	T	12	0.3	14
Totals	T	–	T	–	0.3	–

[1] Number of crops included.

[2] Common names of plants are taken from Kelsey and Dayton (1942). Scientific nomenclature for grasses follows that of Hitchcock (1951), for all other plants it is based upon Small (1933).

[3] Figures are percentages representing dry-weight proportion of total food consumed and frequency of occurrence.

[4] "T" = less than 0.1 per cent.

larly collected from north-central Florida from 1950 through 1952.

The dry-weight method was used in the analysis of individual crop contents. Each food item observed was then expressed as a percentage of the aggregate dry weight. Frequencies of occurrence for the various items encountered were also calculated, based on the entire series of crops for each locality and month.

PLANT FOODS

Data gathered in the present investigation agree with the findings of workers elsewhere, which show the mourning dove to be almost exclusively a vegetarian. Accordingly, October crops from both southeastern and north-central Florida contained over 99.9 per cent vegetable matter, whereas birds collected in December in north-central Florida consumed 99.7 per cent plant material (Table 1).

The largest amount of food recorded from any one crop was 11.43 gm. This came from a bird shot near Homestead, Dade County, on October 12, 1950. Quite likely, it represents almost the maximum capacity of a dove crop. The average crop examined, however, contained approximately one-fifth of this amount, but southeastern Florida crops

averaged about twice (3.10 gm.) the amount contained in crops collected in north-central Florida (1.61 gm.).

October plant foods.—Marked differences in major foods consumed in October by doves in Dade and Alachua counties are apparent from an examination of Table 1. According to this table, 78 per cent of the food consumed by southeastern Florida doves consisted of pricklepoppy and ragweed. Croton was another important food. Also consumed during this period were seed from paspalum grasses, knotroot bristlegrass, carpetgrass, and common pokeweed. Corn comprised only 0.6 per cent of the total diet.

Major foods of mourning doves collected in north-central Florida during the month of October consisted of peanuts and corn, these two items alone comprising 80 per cent of the total food consumed. Other important foods were knotroot bristlegrass and croton. Foods of lesser importance included common pokeweed, paspalum grasses, panic grasses, treadsoftly, and ragweed.

December plant foods.—Crops from birds collected in December from Alachua County suggest food habits quite similar to those reported for October, but December birds had an even more restricted diet. Peanuts and corn composed 92.7 per cent of the total food consumed. Ragweed was also a relatively important food. Together these three plant species comprised 97.6 per cent of all food consumed.

ANIMAL FOODS

Animal foods were usually present in dove crops in only "trace" amounts, but during December north-central Florida crops contained approximately 0.3 per cent animal matter. Most animal foods were doubtless ingested accidentally in the course of normal feeding activities. Such foods included grasshopper eggs (*Melanopus* sp.), ground pearls (encysted forms of scale insects, probably *Margarodes* sp.), phasmid eggs, sow bugs, and beetle fragments. These foods closely resemble plant seeds in appearance. Snail shells, ants (*Monomorium* sp.), and clover seed chalcids (*Bruchophagus gibbus*) were other animal foods that occurred in dove crops.

DISCUSSION

Most investigators of mourning dove food habits regard seeds of the grass family as the most generally important food, comprising from 40 to 75 per cent of the total diet (Cummings and Quay, 1953; Knappen, *op. cit.*; Korschgen, 1955; Martin, Zim, and Nelson, 1951; McClure, 1943; Moore and Pearson, 1941; Pearson and Webb, 1942; and Rosene, 1939). Other plant families utilized by doves include legumes (3–15 per cent), spurges (5–8 per cent), ragweed (1–5 per cent), sedges (1.5–4 per cent), and pokeweed (0.2–7 per cent).

The food habits of southeastern Florida doves are quite distinctive in the predominance of pricklepoppy and the major importance of ragweed. Spurges comprised the third most abundant family of plants. Seeds of grasses ranked fourth in importance, differing markedly from the situation elsewhere in the South. Legumes were of relatively insignificant value to doves in this region.

North-central Florida doves were similar to birds in other parts of the South in their extensive use of grass seeds. These comprised 48.7 and 43.7 per cent of the total food for the months of October and December, respectively. The abundance of legumes was the chief difference in the food habits of north-central Florida doves and those of birds in other sections of the South. These seeds, consisting almost exclusively of peanuts, comprised between 40 and 50 per cent of the diet of Alachua County doves.

Dissimilarities in the food habits of doves in the two portions of Florida are undoubtedly explained by differences in the agricultural crops grown. In southeastern Florida, where various truck crops are produced extensively, pricklepoppies (principally *Argemone leiocarpa*, which, according to Small, 1933, is restricted to south peninsular Florida and the Keys) and ragweed are common agricultural weeds. Although corn is grown, it is usually of the sweet type, and is picked during the spring rather than left standing in the fields—hence, the abundance of pricklepoppy and ragweed, and the scarcity of corn in southeastern Florida dove crops.

The predominance of peanuts and corn in dove crops from north-central Florida is related to the fact that these two crops are commonly grown together throughout this section of the state. This combination of crops is frequently used for hog feed. Hogs are essential to attract doves to peanut and corn fields. They make abundant food available for doves by breaking open ears of corn and scattering the kernels on the surface of the ground and also by rooting out peanuts from the soil and shelling them.

Ragweed and sometimes pricklepoppy also occur as weeds in crop fields of Alachua County. However, the relatively minor importance of the former and the absence of the latter in crop contents of north-central Florida doves suggest that these foods are less highly preferred than either peanuts or corn.

SUMMARY

Food habits of 277 mourning doves are reported for the month of October in southeastern Florida (e.g., Dade County) and for both October and December in north-central Florida (e.g., Alachua County). Plant foods comprised an excess of 99.7 per cent of the total food consumed. Principal sources of foods for doves in Dade County during October were pricklepoppies, ragweed, croton, and paspalum grasses. Peanuts and corn were the chief foods of doves in Alachua County during both months. Additional foods in October were knotroot bristlegrass, croton, and common pokeweed. In December, ragweed was also an important food.

The foods of Dade County birds differ markedly from those of birds in other portions of the South in the relative unimportance of grasses and the predominance of both pricklepoppies and ragweed. Alachua County doves differ in the abundance of legumes (chiefly peanuts) in their diet. Differences in the food habits of doves from the two sections of Florida considered are related to the principal agricultural crops grown in each section.

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FURTHER NOTES ON QUAIL DENSITY AND FARM COMPOSITION[1]

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In a recent issue of *The Journal of Wildlife Management* (22[3]:283–291), the writer and Samual H. Brooks presented some statistical aspects of the relationship of quail density to farm composition in Tennessee. Prior and subsequent to the publication of this manuscript, interest was expressed in an analysis of the raw data in which one would correlate the number of coveys per 100 acres with the percentage of various land-use types in the total farm acreage, rather than a correlation of total coveys and total acreage in various land-use categories, as applied in the original manuscript. This interest apparently arose because wildlife biologists consider desirable habitat composition in terms of percentages of the total.

The present paper contains the results of a regression analysis of these data on the basis of quail coveys per 200 acres of the sampling area and the percentage of the total sampling area in pasture, cropland, and woodland for three Tennessee farming-types.

The reader should not conclude that the writer recommends such a procedure for studying the relationship of quail density to farm composition. The paper is strictly concerned with answering the question, "What are the results if you study the correlation this way?" An elementary discussion of the pitfalls involved in this procedure has been presented by W. A. Wallis and H. V. Roberts (1956. Statistics: a new approach. The Free Press, Glencoe, Ill., pp. 546–549). Since details of sampling and analytical procedures and characteristics of the farming-types have been published in the initial manuscript, only material essential to continuity of thought will be repeated here.

On the basis of the entire sampled area within a farming-type, the number of coveys per 200 acres are as follows: farming-type III, 7.2; farming-type VII, 4.2; farming-type X, 2.6 coveys per 200 acres. The data were collected by personal interview of farmers selected by a procedure known as "area sampling." Heads of farm households furnished information on (a) farm composition in terms of acres and (b) the number of fall coveys utilizing their farms. As sampling areas usually contained more than one farm household, area totals rather than farm totals were utilized in the analysis. Respondents were requested to furnish information on the total acreage of cropland, pasture, and woodland on their farm. Hay and fallow land were classified as pasture. The total area acreage consisted almost entirely of these three classifications of land use.

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TABLE 1.—PARTIAL-REGRESSION COEFFICIENTS, VARIANCES AND COVARIANCES FOR MULTIPLE-REGRESSION MODEL WITHOUT INTERACTIONS

Farming-type	III	VII	X
Partial-regression coefficients			
$b_1 \times 10^3$ (% pasture)	14.8	–25.6	1.2
$b_2 \times 10^3$ (% cropland)	–52.1	–34.7	5.4
Estimated variance $\times 10^5$			
b_1 (% pasture)	168.8	20.7	11.0
b_2 (% cropland)	129.5	31.2	19.3
Estimated covariance $\times 10^5$			
b_1 and b_2	85.9	5.4	5.1

The results of a multiple-regression analysis of coveys per 200 acres on the percentage of the total farm in pasture and cropland are presented in this paper. Since any one percentage is a linear function of the remaining two, the regression model allows a maximum of only two "independent" variables. The assumptions involved in this analysis are those discussed in the initial paper. Again the statistical results are concerned with association and do not imply causation.

In interpreting the results of a multiple-regression analysis of this type, it is wise to inspect the linear correlation between the so-called "independent variables." The product-moment correlation coefficients for percentage of pasture and percentage of cropland are –0.58, –0.21, and –0.35 for farming-types III, VII, and X, respectively. In farming-types III and X, they were significantly different from zero (1 per cent level of significance). The linear association between the variables and the fact that the percentage of woodland is a linear function of the other two variables preclude a reliable estimate of the magnitude of the "effect" of the individual variables on quail density. As in the initial paper, one is also interested in the results of a regression model involving only one of the independent variables. This linear relationship of coveys per 200 acres to each of the percentages (pasture and cropland) can be evaluated by means of the product-moment correlation coefficient. The computed product-moment correlation coefficient for the correlation of coveys per 200 acres with percentage of pasture are 0.17, –0.14, and 0.00, for farming-types III, VII, and X, respectively; for percentage of cropland, they are –0.23, –0.16, and 0.03 for farming-types III, VII, and X, respectively. Only –0.23 was significantly different from zero (5 per cent level of significance). These results imply that, in this study, only a maximum of 5.29 per cent of the total variation in covey density could be "attributed" to percentage of pasture or cropland on the sampling area.

Utilizing two "independent" variables (percentage of pasture and percentage of cropland) in a multiple-regression model, I computed the partial-regression coefficients, their variances, and covariances (Table 1). Application of the test procedure presented in the initial manuscript disclosed that there was no significant difference (5 per cent level of significance) between coefficients within any farming-type. In addition, none of the individual coefficients were significantly different from zero (5 per cent level of significance); however, in farming-type VII, the computed *F*-ratios (3.16 and 3.87) were of the magnitude of the critical value (4.04). The total sum of squares due to the regression of coveys per 200 acres on percentage of pasture and percentage of cropland in each of the three farming-types is presented in Table 2. Only in farming-type VII was there a significant reduction in the total sum of squares as a result of fitting the regression model to the data. These results are not a contradiction of the results of the individual tests of significance of the regression coefficients, as in farming-type VII the computed *F*-ratios are of the order of magnitude of the critical value. In Table 2, it is evident that the sum of squares due to regression in farming-types III and X is only a very small percentage of the total sum of squares. This implies that there is little, if any, linear "relationship" of percentage of pasture and percentage of cropland to quail density in the populations of interest. In farming-type VII, 54.7 per cent of the total variation in covey density is "attributable" to the regression on the two variables, percentage of pasture and percentage of cropland.

I conclude that, in the three Tennessee farming-types studied, there is little, if any, linear correlation of quail density (expressed as quail per 200 acres) to the percentage of pasture, the percentage of cropland, or the percentage of woodland acreage.

TABLE 2.—RESULTS OF THE MULTIPLE REGRESSIONS OF NUMBER OF COVEYS PER 200 ACRES ON PERCENTAGE OF PASTURE AND PERCENTAGE OF CROPLAND IN TOTAL SAMPLING AREA

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	*F*
FARMING-TYPE III				
Due to regression	2	95.58	47.79	2.14
Residual	74	1653.84	22.35	
Total	76	1749.42		
FARMING-TYPE VII				
Due to regression	2	119.54	59.77	29.01*
Residual	48	98.96	2.06	
Total	50	218.50		
FARMING-TYPE X				
Due to regression	2	0.60	0.30	0.08
Residual	136	534.03	3.93	
Total	138	534.63		

* Significant at the 0.5 per cent level of significance.

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MINERAL ANALYSES OF LIVERS AND KIDNEYS OF MOOSE (*ALCES AMERICANA*)

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This paper presents some information on the mineral content of moose livers and kidneys. The determinations presented were made to test the hypothesis that abnormal moose in Nova Scotia were suffering from a mineral imbalance.

Sixteen animals collected in Nova Scotia exhibited abnormal behaviour. The syndrome has been described (Fenstermacher and Jellison, 1933; Fenstermacher, 1934, 1937; Fenstermacher and Olsen, 1942; Benson, 1958a). Individual case histories were recorded (Benson, 1955).

Comparative material was obtained from ten Newfoundland animals through the courtesy of D. H. Pimlott, then of the Newfoundland Department of Natural Resources. The "sickness" or "disease" studied in Nova Scotia and present also in New Brunswick is unreported from the Newfoundland herd, which developed from introductions originating in the mainland provinces at the turn of the century (Pimlott, 1953).

The interest and co-operation of the Nova Scotia Research Foundation (H. D. Smith, President), and of the Nova Scotia Department of Agriculture (G. R. Smith, Director) made possible quantitative spectrographic and chemical analyses.

Methods

Samples were stored in glass containers at the time of collection. They were weighed, charred, reweighed, and again stored in glass. Charring was carried out in "pyrex flame-ware" dishes in a sheet-iron oven heated by a gasoline camp stove. The samples were then delivered to the laboratory.

Chemical procedures employed included variations of standard techniques. For this reason, methods are presented in some detail.

Samples were digested by mixture of sulphuric and perchloric acids. Ten gm. of tissue char were weighed and placed in a 500-ml. Kjeldahl flask and 25 ml. of concentrated H_2SO_4 added. The resulting mixture was heated until foaming had ceased. The mixture was cooled, and 5 ml. of 72 per cent $HClO_4$ added and heated gently for a few minutes until a straw-colored solution was obtained. Further additions of $HClO_4$ were sometimes necessary at this point to combust all the organic material present and to obtain the desired straw color. The solution was then cooled, and 50 ml. of H_2O added, filtered through Munktell's No. 0 filter paper, washed with cold water, and made up to a 250 ml. volume. Aliquots were taken, and the concentration procedure of Mitchell (1948:118–130) was followed.

Following the H_2SO_4–$HClO_4$ digestion procedure, cobalt, molybdenum and zinc were determined spectrographically. An applied-research spectrograph fitted with a 1.5-m. grating was used. Check determinations were carried out at least once and often twice on every sample.

The H_2SO_4–$HClO_4$ digestion procedure was also used for determining copper, colorimetrically. All apparatus was washed with hot concentrated HNO_3 before determining copper, to ensure copper-free apparatus. Aliquots were placed in 150-ml. separa-

Table 1.—Results of Chemical Analysis of Nova Scotia Material

(Concentration of elements in p.p.m. in original organic samples)

Moose No.	Co	Mo	Zn	Cu
		Liver Samples		
M-51-17	0.08	0.14	57.1	86.2
M-51-20	0.11	0.44	80.0	69.1
M-51-21	0.13	0.80	108.3	18.8
M-51-22	0.09	0.71	56.2	43.6
M-51-23	0.09	0.47	80.1	79.0
M-51-24	0.08	0.42	26.1	40.9
M-51-25	0.16	0.79	54.5	33.1
M-52- 1	0.21	0.30	129.9	9.9
M-52- 2	0.11	0.36	59.4	82.2
M-52- 4	0.11	0.47	60.8	49.7
M-52- 5	0.15	0.63	171.9	96.2
M-52- 6	0.11	0.23	113.0	68.3
M-52- 8	0.07	0.20	28.2	56.0
M-52-26	0.11	0.10	19.6	37.0
M-53- 5	0.12	0.28	80.2	42.0
M-53- 6	0.07	0.11	45.6	46.6
		Kidney Samples		
M-51-17	0.05	0.21	29.1	24.9
M-51-20	0.10	0.34	63.2	6.3
M-51-21	0.09	0.58	42.8	10.6
M-51-22	0.07	0.05	37.3	7.3
M-51-23	0.05	0.08	68.1	7.0
M-51-24	0.05	0.43	44.8	11.8
M-51-25	0.05	0.51	109.0	15.7
M-52- 1	0.07	0.10	63.7	9.3
M-52- 2	0.05	0.06	35.5	1.4
M-52- 4	0.06	0.05	60.9	2.7
M-52- 5	0.08	0.12	64.9	9.6
M-52- 6	0.06	0.10	68.9	5.4
M-52- 8	0.07	0.18	40.8	2.5
M-52-26	0.06	0.09	30.7	2.8
M-53- 5	0.04	0.10	61.9	5.7
M-53- 6	0.03	0.07	24.1	7.3

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TABLE 2.—RESULTS OF CHEMICAL ANALYSIS OF NEWFOUNDLAND MATERIAL
(Concentration of elements in p.p.m. in original organic samples)

Moose No.	Co	Mo	Zn	Cu
		Liver Samples		
1	0.08	0.36	32.1	41.7
2	0.09	0.47	33.5	50.2
131	0.06	0.46	158.1	40.2
132	0.12	0.30	26.9	56.4
133	0.09	0.44	37.3	97.8
135	0.08	0.38	109.0	35.4
137	0.08	0.17	40.6	32.3
138	0.08	0.16	22.0	337.5
139	0.69	0.41	34.8	41.6
140	0.04	0.50	30.9	54.3
		Kidney Samples		
1	0.08	0.17	22.1	7.5
2	0.06	0.18	32.4	5.6
132	0.05	0.13	24.7	5.5
135	0.05	0.10	73.3	9.5
137	0.09	0.35	34.0	12.6
138	0.06	0.27	36.4	56.1
139	0.04	0.17	30.2	8.5
140	0.06	0.20	48.5	4.4

tory funnels. Five ml. of 15 per cent citric acid were added and enough NH_4OH to make the solution just basic to litmus. Two ml. of a 1 per cent solution of sodium diethyl dithiocarbamate were added and the solution shaken. Fifteen ml. of isobutonal were then added, and the solution again shaken vigorously and allowed to stand. The aqueous phase was separated from the alcohol phase, and the latter was placed in colorimeter tubes. The intensities of color were read by means of an Evelyn colorimeter and a 440-Mμ filter and compared to a standard curve prepared from known solutions of copper concentration.

RESULTS AND DISCUSSION

One of the liver samples from Newfoundland had a cobalt content of 0.69 p.p.m., which is abnormally high when compared to the other values found for the same element in such samples. When this unusually high value is omitted, the average of other values found for liver samples from Newfoundland specimens is 0.08 p.p.m. This is considerably lower than the comparative average of 0.11 p.p.m. for the samples from Nova Scotia moose. The cobalt content of the kidney from the moose showing unusually high cobalt in the liver (0.69 p.p.m.) was unusually low, at 0.04 p.p.m. The averages of cobalt content of 16 kidney samples from Nova Scotia and 8 kidney samples from Newfoundland are almost identical.

One Newfoundland sample (No. 138) showed 337.5 p.p.m. copper in the liver and 56.1 p.p.m. in the kidney. These values are very high in comparison with those found in the other samples of the same types of tissue. If these high values are omitted, the average for the Newfoundland moose liver samples becomes 50.0 p.p.m. and for the kidney samples 7.7 p.p.m. These values compare very closely with the values of 53.7 and 8.1 in the comparative tissue samples from Nova Scotia.

TABLE 3.—COMPARISON OF NOVA SCOTIA AND NEWFOUNDLAND RESULTS
(Summary of data presented in Tables 1 and 2)

Organ	Element Tested	Nova Scotia		Newfoundland	
		Mean	S.E.	Mean	S.E.
Liver	Cobalt	0.11	0.009	0.08[1]	0.007
	Molybdenum	0.40	0.058	0.36	0.038
	Zinc	73.2	10.21	52.5	14.09
	Copper	53.7	6.15	50.0[1]	18.77
Kidney	Cobalt	0.06	0.005	0.06	0.006
	Molybdenum	0.19	0.044	0.20	0.028
	Zinc	52.9	5.36	37.7	5.82
	Copper	8.1	1.44	7.7[1]	1.07

[1] One extreme value omitted.

The values for molybdenum in the Nova Scotia samples compare very closely with those of the Newfoundland samples.

Both liver and kidney samples showed zinc to be less plentiful in the samples from Newfoundland moose as compared with those from Nova Scotia.

When the figures for all elements are compared, and the 0.69 p.p.m. cobalt value (specimen No. 139–liver), as well as the values of 337.5 and 56.1 p.p.m. copper (specimen No. 138–liver and kidney), are omitted, the Nova Scotia averages are generally higher than those found for the Newfoundland samples. However, the Student *t* test indicates that the only significant difference is the excess of cobalt in the livers of the Nova Scotia specimens (significant at the 5 per cent level).

Associated studies included analyses of 37 species of woody plants for the elements cobalt, molybdenum, zinc, manganese, copper, calcium and phosphorus (Beeler, *et al.*, 1958).

Our raw data are offered here (Tables 1 and 2) so that the Nova Scotia findings may be compared with individual case histories of the abnormal animals that provided the material analyzed. As Table 3 summarizes, we were not able to prove or disprove our hypothesis, partly due to our failure to locate any comparable data for moose in the literature. We present our findings as a minor contribution to the knowledge of the place of minerals in the nutrition of wildlife species.

SUMMARY

Quantitative spectrographic and colorimetric analyses of liver and kidney tissues of 16 unhealthy moose from Nova Scotia and 10 healthy moose from Newfoundland for the elements cobalt, copper, molybdenum, and zinc resulted in the conclusion that the moose in both provinces take up and store similar quantities of these elements except cobalt, the higher content of cobalt being in the livers of Nova Scotia moose.

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THE LENS AS AN INDICATOR OF AGE IN COTTONTAIL RABBITS[1]

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This paper presents a technique for determining the age of cottontail rabbits (*Sylvilagus floridanus*) based on the growth rate of the lens of the eye. The lens of the eye of man and rabbits (and probably most other mammals and possibly birds) grows continuously throughout life. New lens fibers are continuously being proliferated by the growth and elongation of the epithelial cells at the lens equator. The lens fibers at the center of the lens are laid down during intra-uterine life. Because of the avascular nature of the lens and its density, those fibers at the center of the lens lose their cell membrane and become dense and rigid, and their cytoplasm loses water (Lansing, 1952:239–259). The above findings were first demonstrated in the domestic rabbit by Krause (1934:186–191). It is apparent that, providing there is little individual variation in the growth rate of the lens within a species, the growth-rate curve of the lens could provide a tool for determining the age of animals. The results of this study indicate that individual variation in lens size and growth is sufficiently low to make measurement of the lens a feasible method for determining the age of cottontail rabbits.

METHODS

Because of the difficulty of breeding cottontail rabbits in captivity, the rabbits used in this study were obtained from co-operating citizens of the cities of Champaign and Urbana, Illinois, as a result of notices placed in the local newspapers. Most of the rabbits were taken from the nest at approximately 1 week of age. The date of birth of the rabbits was estimated from the weight of the baby rabbits. The lenses of four 1-day-old rabbits were obtained from a litter born to a female that was captured while pregnant and held for the remainder of her term. All of the rabbits were obtained during the summers of 1956, 1957, and 1958. Eight rabbits were obtained the first summer, 30 the second summer, and 54 the third summer for a total of 92 rabbits. The baby rabbits were fed, by medicine dropper, a mixture of 1 part evaporated milk and 2 parts tap water, with a small amount of honey added. Each received several medicine droppers full of milk in the morning and evening. Fresh grass, clover, and vegetables were kept constantly available to the rabbits and, when they had become mature enough to eat large quantities of greens, hand feeding of milk was discontinued. As soon as the feeding of milk was discontinued, a balanced ration of commercial rabbit food was kept constantly available to the young rabbits in addition to the fresh grass, clover, and vegetables. When the young rabbits began to consume large quantities of the commercial food, the fresh-greens diet was discontinued, and thereafter the rabbits were maintained on commercial rabbit food. The rabbits were kept in small cages, each $16 \times 14 \times 36$ in. When weaned, the rabbits were kept out of doors for the remainder of their lives.

A schedule for killing the rabbits was followed as closely as possible (Table 1). On occasion, a rabbit would die from some disease, disrupting the schedule. On these occasions, the schedule was revised to obtain the best spread of ages. The oldest rabbit was kept for 30 months. When a rabbit was killed, the eyes were removed immediately and placed in a solution of 10 per cent Formalin. The purpose of the Formalin was to harden the lens,

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[2] Employed by the Illinois Department of Conservation under terms of the Federal Aid in Wildlife Restoration Act and assigned to the Illinois Natural History Survey for administrative and technical supervision.

TABLE 1.—THE DRY WEIGHT OF LENSES OF KNOWN-AGE RABBITS

Age (days)	Wt. (mg.)	Age (days)	Wt. (mg.)	Age (days)	Wt. (mg.)
1	6.6	69	54.0	243	183.3
1	7.3	69	79.3	246	172.0
1	6.9	87	93.1	258	188.0
1	8.4	92	91.6	268	183.6
7	11.8	92	105.7	271	172.1
7	13.2	97	116.6	271	159.8
7	13.4	104	111.7	281	193.6
14	19.6	109	119.7	281	180.9
14	19.4	124	132.0	301	189.9
14	20.4	124	126.0	328	182.1
14	21.2	131	132.9	328	188.2
14	21.6	136	109.4	332	194.6
14	22.4	141	130.0	338	205.6
21	18.4	146	124.4	338	192.6
21	16.1	146	127.9	371	209.1
21	16.4	160	148.6	396	203.8
21	17.3	183	168.0	398	215.9
21	29.0	183	159.8	427	223.6
31	20.3	189	163.5	458	226.4
31	18.6	189	163.8	458	209.4
44	45.1	194	182.7	489	224.8
45	52.5	201	160.6	521	234.5
45	56.4	201	172.0	584	228.2
45	56.2	209	187.6	610	235.8
47	48.9	216	179.5	731	248.1
52	64.1	224	183.5	762	256.1
52	56.1	224	162.2	791	249.6
54	48.2	228	173.6	825	253.8
55	67.0	228	176.3	854	265.6
57	54.8	228	169.5	914	257.4
64	77.3	236	179.2		

making it easy to separate it from the vitreous humor. A period of 1 week was found to be sufficient for the fixing. The longer the lens was kept in the Formalin the harder it became, making it progressively easier to work with.

Four separate growth-rate curves may be obtained from a series of lenses of animals of known age. The first curve is the wet-weight curve, the second the dry-weight curve, the third the volume curve, and the fourth the per cent dry material curve. To determine which of these measurements gives the most satisfactory curve for the purpose of this study, all four sets of data were taken.

After fixing, the lens was removed from the eye, rolled a few times on a paper towel to remove excess surface moisture and then weighed to the nearest tenth of a milligram. To obtain the volume of the lens, it was suspended on the end of a needle and weighed under water. The loss in weight was considered equal to the volume in cubic millimeters. The lens was then placed in an oven with a fan for circulating air, which was maintained at a temperature of 80° C. Lenses were considered dry when repeated weighings, with intervals of drying, resulted in no additional loss in weight, 24–36 hours being usually sufficient to dry the lenses. Because the dried lenses are hygroscopic, they were weighed immediately after removal from the oven. An ordinary precision balance for weighing chemicals was found to be too slow and to have too large a weighing chamber, because the lenses gained weight while being weighed. A Roller-Smith (Roller-Smith Co., Bethlehem, Pa.) precision balance was found to satisfy the requirements. The total amount of time required to process a lens is approximately 2 minutes of actual work and 7 days of storage in a fixative, plus 1 or 2 days of drying. The number of lenses that can be processed together is dependent only on the size of the drying oven. The author's oven could accommodate 300 lenses in small open-top jars.

RESULTS

The dry-weight data (Table 1) gave the best curve (Fig. 1) for the purpose of this study; the variation between individuals of similar age was the least, and the ascendancy of the curve the greatest for the longest period of time. Because both eyes were taken, it was possible to test the accuracy of the measurements. From the dry-weight data for 83 rabbits, the mean difference between the right and left lenses was 1.2 ± 1.67 mg., or 0.87 ± 1.21 per cent of the dry weight of the lenses. For comparison, the comparable figures for the wet-weight data was a mean difference of 8.2 ± 12.71 mg., or 2.51 ± 3.90 per cent of the wet weight of the lens. The volumetric data were partially based on the wet-weight measurements and are therefore subject to the variation inherent in these measurements. In addition, the effect of surface tension acting on the needle at the point of entrance into the water increases the inaccuracy of the volumetric data. The data concerned with the proportion of dry material of the lenses, when plotted on graph paper, show a wide degree of variation and a curve that bends over sharply at 75 days of age The rate of growth of lenses did not differ noticeably between the sexes of cottontail rabbits. An attempt to relate body weight to the lens weight produced undesirable results. The inclusion of body weight in the analysis introduced a factor with more inherent variation than exists in the lens-weight data.

DISCUSSION

It seems apparent that the use of the lens to determine the age of cottontails will be an improvement over such methods as the epiphyseal-closure technique, because the lens-growth curve permits determination of the month of birth of the younger rabbits and the year of birth of rabbits older than 1 year. Although the data are not presented in this paper, the author has sufficient evidence from other species of mammals to indicate that the lens technique for determining age will be applicable to most other mammals. There is not yet sufficient evidence to make a corollary statement for birds.

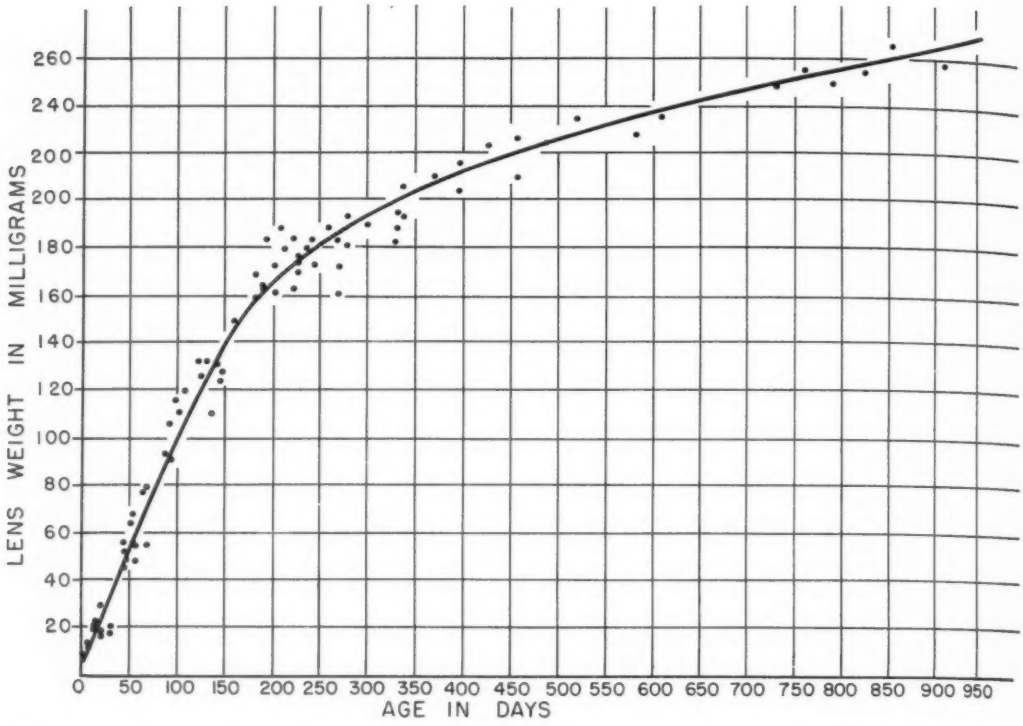

FIG. 1. The dry-weight, growth-rate curve of the lens of the eye, based on 92 cottontail rabbits of known age.

For deer (*Odocoileus, Alces,* etc.) or the gray fox (*Urocyon cinereoargenteus*), this technique may possibly be superior to the tooth-wear techniques because it is probably less sensitive to nutritional deficiencies, and it avoids the difficulty sometimes caused by increased tooth wear due to excessively sandy soil in some regions. Because the final determination of the age of an animal when aged by the lens technique is done by a trained technician in the laboratory and is based on numerical values, there is probably less chance for error than in a technique that is based on estimations of age from such characteristics as the amount of tooth wear.

ACKNOWLEDGMENTS

I am grateful to David Casteel and Sara Josephine Ferris for taking care of the rabbits. Miss Ferris also contributed by weighing many of the lenses and executing the schedule for killing the rabbits. I am indebted to the editorial committee of the Section of Wildlife Research of the Illinois Natural History Survey and Thomas G. Scott for advice in the preparation of the manuscript. The late Jonas Friedenwald gave advice at the initiation of this project.

SUMMARY

This paper presents a technique for determining the age of cottontail rabbits based on the growth rate of the lens of the eye. Ninety-two cottontail rabbits were raised in captivity and killed on a schedule over a period of 30 months. A growth-rate curve for the lenses of the rabbits was plotted from the weights of the dried lenses. The resultant curve proved to be suitable for estimating the age of wild rabbits whose lenses had been removed, dried, and weighed.

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TRACK DIFFERENTIATION FOR CENSUSING BEAR POPULATIONS[1]

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This report concerns the use of the track-count census method as a part of a population study of the brown bear (*Ursus arctos*) on Admiralty, Baranof, and Chichagof islands, Alaska, during the summer of 1958. Objectives of the study included the development and testing of population indices adaptable for use in the dense rain-forest habitat of the brown bear. Information was needed as a basis for the establishment of a forest-management program which will ensure the welfare of the brown bear in the presence of a rapidly developing timber industry.

Procedure

In 1932, F. Dufresne and J. P. Williams (Admiralty Island Bear Estimate, Alaska Game Commission and U.S. Forest Service, 8pp. mimeo.) first used a track-count method to census brown bears on Admiralty Island. This method was tested in 1958 on southern Admiralty Island to determine its reliability as a population index. The actual procedure for measuring and differentiating bear tracks was basically quite similar to that used in 1932, as stated by Dufresne and Williams. "In estimating the bears along the creeks, we were guided by several factors. First and foremost was [*sic*] the highly individual tracks of the animals. They were different in size, different in shape, with other more or less noticeable characteristics which would enable us to recognize them from any other tracks. . . . We came to an agreement that the most reliable measurement we could take was the width of the bear tracks across the toes. . . . Taking into consideration the medium in which the tracks were made, [and] measuring the same track over and over again where the animals had walked over gravel bars, sand flats and mud holes, we found that we could secure reliable measurements within a quarter of an inch, and further that we could recognize the same track if encountered at other places. Additional strength was given this method by also taking the length of the track from heel pad to middle toe, exclusive of the nail, whenever possible, but by itself this was not a reliable measurement owing to slippage, nature of soil, etc., and must be secondary to the measurement across the toes. We were further aided in this by the fact that some bears had long, narrow soles; others were broad and rounding as though the animal had suffered fallen arches, while others were ham-shaped." In the 1958 studies, we found less individual track variation than indicated by Dufresne and Williams and were unable to identify individual tracks except through measurements. We also found the width of the forepad to be more accurate than the width across the toes, a measurement which varies more widely with the ground conditions.

The study area included approximately 35 salmon streams and the intervening areas on southern Admiralty Island from Gambier Bay to Hood Bay. Suitable tracking medium, in the form of sand bars and mudbanks, was distributed along approximately 40 per cent of each stream walked, although some variation existed between streams. While bears generally restrict themselves to small activity areas here if salmon are abundant, they do travel extensively within these areas, moving from sand bar to mudbank in pursuit of fish. The average length of stream utilized by salmon and, consequently, by bears was approximately 1¾ miles, with the greatest length being 5¾ miles. Heavy rains sufficient to obliterate tracks in sand and mud occurred on 7 of the 15 days of the study period (August 5–19, 1958). The field data were gathered by five two-man crews who were shuttled by helicopter to above the limit of salmon on the streams and measured and tallied tracks as they returned to salt water.

In addition to the actual measurements of bear tracks adjacent to the streams walked, other pertinent observations were recorded in an attempt to standardize and simplify evaluation of the many variables involved in the counts. As an aid in determining variation to expect in each track measurement, the type of ground surface (soft sand, hard mud, etc.) and whether the track was distinct or indistinct were recorded. Variable environmental factors that affect the concentration of bears on the streams were also recorded, such as numbers and extent of salmon in the streams, location of salmon obstructions, and availability of salmon as determined by stream water levels and turbidity. A current phenological record was kept for the study area, in which periodicity of the salmon escapements, small-mammal abundance, success of the berry crop, and other conditions affecting bear distributions were listed. Ideally, the track counts should be co-ordinated with the peak of the salmon runs when bears are concentrated on the streams. However, chronological variation in salmon escapements into the streams within any given area necessitated planning field work to coincide with suitable conditions on the greatest portion of streams.

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Collection of track-count data on some streams required a special approach to minimize counting of duplicate tracks when heavy concentrations of bears were encountered. Generally, there was no problem on streams with less than six or seven bears present. However, on the major salmon streams where there were frequently as many as ten bears per mile of stream, the differentiation of individual bears from the abundance of tracks measured became more difficult. In these instances, division of the stream into workable segments not greater than a mile in length simplified counting. Bears were found to move less on the streams where fish were abundant and, therefore, were not as likely to move from one segment to another, as on the smaller streams. However, the determination of the extent of track duplications presented many complications and remained an inherent problem in the areas of heavy bear concentration. Cub tracks posed an additional problem, as individual track variation within a litter was usually not great enough to allow determination of the number of cubs present. To compensate for this, all groups of new and yearling cub tracks encountered were adjusted according to mean litter-size values determined from sight records.

A further check of the track-count method was made to determine the variation which occurs with varying abundance of salmon in the streams. On August 18, ten days after the last track counts had been completed in Gambier Bay, a complete replication of the counts was made on all streams in the bay. The second count recorded 36 bears, or a 44 per cent decrease from the earlier count of 64. At the same time, the number of live salmon in the streams showed a corresponding average decrease of 40 per cent. Abundance and availability of berries and other environmental conditions were relatively constant for the two counts.

DISCUSSION AND CONCLUSIONS

In reviewing the results of the track counts it was obvious that many possibilities existed for variations in the counts. Factors that affected tracking conditions, such as frequency of rains and condition of the substrate, were not serious obstacles. Taking the counts 1–2 days after heavy rains had obliterated old tracks greatly facilitated the counting and reduced the likelihood of the same bears being counted on adjacent streams. Substrate was found to be of less importance than was anticipated. With few exceptions, suitable tracking medium was present and well dispersed on the streams. It was important, however, to avoid counting after long rainy periods when high waters covered the sand bars and mudbanks, which were the best places to locate tracks.

It was evident that environmental variables, such as the abundance and availability of both salmon and berries, played an important part in determining the distribution of bears. The replicate counts in Gambier Bay emphasized the importance of salmon in attracting the bears to the streams. An additional comparison can be made with the 1932 Admiralty Island counts, which yielded a figure of 362 bears on the same salmon streams on which the 1958 counts indicated a figure of 187 bears. While specific population levels are not known for these two periods, harvest data from bear trophy hunting, collected since 1945, indicate that no significant reduction in population has taken place since that date (D. R. Klein, 1958. Southeast Alaska brown bear studies. U.S. Fish and Wildl. Serv. Unpubl. P-R report, Alaska W-3-R, 21pp.). I feel that the wide variation in the counts is essentially the product of the varying environmental conditions that existed, rather than differing population levels. During the summer of 1932, there was a good salmon escapement; however, the berry crop was poor. The 1958 counts were made during a season of poor salmon escapement but excellent berry production. Apparently, more bears were attracted to the salmon streams in 1932 by the abundance of salmon, while in 1958 the scarcity of salmon and the good berry crop had the opposite effect. While the effect of these variables was apparent in a general way, it was not possible to evaluate their specific effects in terms of variations in numbers of tracks counted.

The greatest obstacle in using the track-count method as a population index is in adequately determining the proportion of bears not utilizing the salmon streams at the time of the counts. Dufresne and Williams estimated that in 1932, 10 per cent of the bears were on vegetative diets away from the salmon streams. During the 1958 studies, we attempted a similar estimate based on random transects walked from alpine areas to sea level. Also, aerial counts were flown in the alpine areas. Both of these approaches failed to yield a reliable basis for estimating the numbers of bears in areas away from salmon streams.

Results of the 1958 studies indicate that variables inherent to the track-count method render it unsuitable as a population index under Alaskan conditions. Dufresne and Williams undoubtedly encountered similar variables in 1932 but failed to stress their importance to the results of their counts. In the light of the results of the 1958 studies, the accuracy of the 1932 counts cannot be relied upon.

Although the track-count method has not proved practical as a bear census method, it does have value as an indicator of relative abundance or seasonal usage if restricted to small units, such as salmon-stream drainages. The method will be useful in Alaska to reflect annual variation in bear use of salmon streams associated with logging. It should be born in mind, however, that reliability of the method decreases as the size of the area studied is increased.

SUMMARY

Testing of the track-count method for censusing brown bears is described. Tracks were measured and tallied adjacent to salmon streams, and bears

were differentiated on a basis of variation in track size. Salmon abundance, the success of the berry crop, and other variables were found to influence the distribution of bears, but their specific effect on the counts could not be evaluated. Determination of the proportion of bears away from the salmon streams was not possible. The track-count method proved to be ineffective as a population index but is of value for determination of relative or seasonal abundance on small areas.

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A FLEXIBLE, PLASTIC EARTAG FOR RABBITS[1]

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This paper describes an improved technique for marking wild cottontail rabbits (*Sylvilagus floridanus*) with plastic eartags for subsequent identification of individual rabbits in the field. The use of this eartag eliminates the need for retrapping rabbits in studies of population turnover and movements, and also facilitates behavorial studies.

Numerous workers have marked wild rabbits by fastening plastic tags or discs to the ears. Niethammer (1937) attached white, numbered tags to the ears of rabbits (*Oryctolagus cuniculus*), but did not describe fully the marking technique. Trippensee (1941) attached pyralin, plastic washers of various color combinations to the ears of cottontail rabbits with staples. Hosley (1942) reported the attachment of small, celluloid washers to the ears of cottontail rabbits. Southern (1940), Tyndale-Biscoe (1953), and Thompson and Armour (1954) marked *O. cuniculus* with small, plastic discs attached to the ears by various types of fasteners.

Plastic discs, with rivet-type or fixed-staple fasteners, have two principal difficulties in field use: (1) Necrosis of the ear tissues frequently occurs at the point of attachment of the fastener, and causes many tags to fall out or to be torn out (Tyndale-Biscoe, *op. cit.*; Thompson and Armour, *op. cit.*); and (2) the position of attachment and smallness of the numbered discs do not permit individual identification of rabbits except at short distances (about 20–60 yd.) and under the most favorable lighting conditions (Trippensee, *op. cit.*; Thompson and Armour, *op. cit.*).

METHODS

The flexible, plastic eartags described in this paper were constructed from Masland Duran upholstery plastic, which is 0.016 in. thick. This plastic is available (in several colors) through F. A. Rauch and Co., 211 S. Peoria, Chicago 7, Illinois. The plastic was cut into 2-in. squares, and the desired numeral or letter was painted on each half of the square (Fig. 1, upper left). The numerals or letters were formed with RamCote vinyl plastic paint and were about 1⅛ in. tall. The paint is available (in several colors) through RamCote Products, Chicago 21, Illinois.

In attaching the plastic tag, one folds it over the anterior edge of the ear of the rabbit so that the numeral or letter is visible on each side of the ear (Fig. 1, upper right). The plastic tag is fixed in position with a No. 3 Monel-metal, self-piercing eartag. The metal tags are manufactured and sold by the National Band and Tag Co., Newport, Kentucky. The pliers designed by the company for attaching this metal tag cannot be used, because the additional bulk of the plastic prevents the proper crimping of the metal tag. Therefore, the pointed tab of the metal tag must be partially straightened and inserted through the plastic tag and ear by hand. After the metal tag has been inserted through the plastic and the ear and moved into position at the first point of insertion, the tab is rebent and forced through the plastic and ear at the second point of insertion (Fig. 1, lower left). The self-piercing metal tag is then crimped with long-nosed electrician's pliers, and the attachment of the marker is completed (Fig. 1, lower right). The metal tag pierces the plastic tag in two places on each side of the ear; thus, the plastic tag is held at four points by the metal tag. The plastic fold covering the auditory portion of the ear may be trimmed at the lower edge with scissors, so that the auditory sense of the rabbit will not be impaired.

The numerals and letters applied to the plastic markers by the writers were restricted to single digits or letters to enable accurate identification of rabbits at distances greater than 100 yards. A series of ten digits and 16 letters (ten letters were not used because of possibility of confusion with other letters or numerals) were combined with accompanying supra-numeral or -literal symbols of a bar, a single dot, and double dot to give a total of 104 combinations for each background color of plastic.

[1] Contribution from Pittman-Robertson Research Projects Nos. W-30-R and W-42-R, the Illinois Department of Conservation, the U.S. Bureau of Sport Fisheries and Wildlife, and the Illinois Natural History Survey, co-operating.

[2] The authors are employed by the Illinois Department of Conservation under terms of Federal Aid in Wildlife Restoration Act and assigned to the Illinois Natural History Survey for administrative and technical supervision.

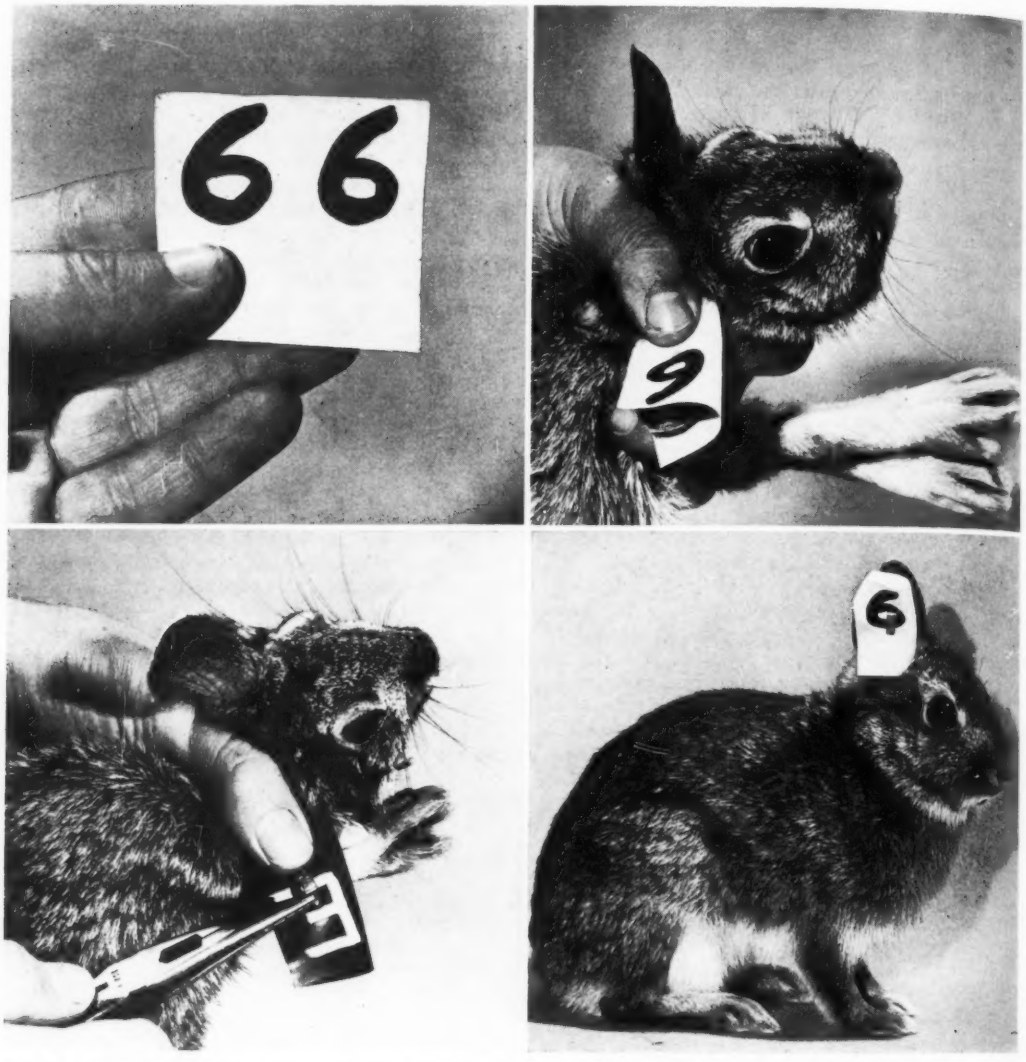

FIG. 1. Upper left: Plastic eartag ready for attachment; Upper right: Eartag in position for fastening with metal tag; Lower left: Pointed tab of metal tag rebent and in position for insertion at second point; Lower right: An attached plastic eartag; this tag has not been trimmed across the auditory portion of the ear.
(Photos by William E. Clark, Illinois Natural History Survey photographer.)

Males and females were marked with differently colored plastics to facilitate studies of behavior and movement. Differently colored plastics were also used for each trapping period to permit the estimation of mortality between trapping periods.

FINDINGS

One hundred and seven cottontail rabbits (52 males and 55 females) were trapped, marked with the flexible, plastic eartag, and released on an intensively cultivated 23,200-acre study area in east-central Illinois between December 16, 1957, and August 28, 1958. Between the onset of trapping and October 31, 1958, 128 observations of rabbits marked with plastic eartags were recorded. Most of the marked rabbits were observed coincidentally with investigations of pheasant behavior. The eartagged rabbits were individually identified in 115 (90 per cent) of the 128 observations; the color of the background plastic was determined for every eartagged rabbit observed.

Under good lighting conditions, the numerals or letters on the eartags were easily distinguished at distances up to 100 yd. with 7 × 35 binoculars, and up to about 220 yd. with a 20-power spotting scope.

Frequently, the numerals or letters on the eartags were correctly identified on running rabbits at distances of from 10 to 15 yd. without optical aids. The numerals or letters on the eartags were visible from almost any position, provided the rabbit held its ear in an erect position.

Among the 107 rabbits marked with plastic eartags, 68 rabbits (64 per cent) were never observed after the original trapping, 11 (10 per cent) were observed once, 9 (8 per cent) were observed twice, 4 (4 per cent) were observed three times, 9 (8 per cent) were observed four times, and 6 (6 per cent) were observed between five and nine times. Of the 39 rabbits observed at least once, the mean number of observations per individual was 2.9. The mean time-interval between eartagging and the 115 subsequent observations of the 39 identified rabbits was 18.5 days, with extremes of 1 and 297 days. The mean recapture-interval for nine eartagged rabbits that were retrapped prior to August 28, 1958, was 12.2 days, with extremes of 1 and 37 days.

There has been no indication of necrosis or irritation of the ear tissues caused by this marker among either wild rabbits that were recaptured or among caged rabbits on which the eartag was initially tested. Nor has there been any indication of increased mortality among rabbits marked with this eartag. Only one eartag was known to have been lost during the period of this study.

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THE USE OF CURARE AND CURARE-LIKE DRUGS ON ELK (WAPITI)[1]

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The purpose of this paper is to report on the use of curare and curare-like compounds as paralytic drugs to be administered intermuscularly to elk [wapiti (*Cervus canadensis*)] by means of a liquid-filled projectile. The research reported here also includes the testing of a satisfactory antagonizing agent that would be needed when over-curarization occurs. This work was done in 1952 and 1953 and was not thought significant until the use of nicotine alkaloids on elk was attempted. Preliminary results with the use of nicotine alkaloids on elk have been unsatisfactory. In seven trials, no satisfactory paralysis and one death has occurred. Apparently no drug, other than the curare drugs, is a satisfactory paralyzant for elk. Hall, *et al.* (1953) have reported on the successful use of Flaxedil as a paralytic drug for white-tailed deer (*Odocoileus virginianus*). Crockford, *et al.* (1957) have shown that a paralytic drug can be delivered to large game animals in the field by means of a projectile.

[1] Contribution from Federal Aid in Wildlife Restoration Act Project W-27-R, Wyoming. Acknowledgment is due to the personnel of FA Wyoming Project No. W-31 for trapping the elk for this experimental work, and to the various pharmaceutical concerns who offered advice and literature on the use of their products for the experimental work.

MATERIALS AND METHODS

Four elk were available for use in these experiments. They were held in a small pen that permitted access to a scale and bleeding chute.

Flaxedil, a synthetic curare drug [*v*-phenenyltris (oxyethylene)-tris (triethylammonium iodide), donated by Lederle Laboratories Division, American Cyanamid Company, Pearl River, New York], Metubine iodide, a modified natural curare drug [dimethyltubocurarine iodide, donated by Eli Lilly and Company, Indianapolis, Indiana], and *d*-tubocurarine chloride, a natural-occurring curare drug, were used in these experiments. Tensilon [(3-hydroxyphenyl) dimethylethyl ammonium chloride, donated by Hoffman, LaRoche Inc., Nutley, New Jersey], a synthetic antagonizing material for Metubine iodide, *d*-tubocurarine and Flaxedil, was also used in these experiments.

Animals were weighed to the nearest pound. Dosages of each drug were calculated from the body weight of the animal. Drugs were injected hypodermically into the large muscle of the rump. Immediately after injection, the animal was moved from the chute and kept exercising until paralysis occurred or until it was apparent that there would be no paralysis. Each series of dosages was continued until it was necessary or nearly necessary to give the antagonist to restore normal respiration. A

TABLE 1.—THE EFFECT OF FLAXEDIL ON ELK

BODY WEIGHT (Lb.)	DOSAGE (Lb. per 1 Ml.[1])	TOTAL DRUG (Mg.)	TIME OF PARALYSIS	
			Onset (Min.)	Duration (Min.)
260	130	40	No effect	None
210	120	35	No effect	None
220	110	40	7	14
225	100	45	9	21
236	90	52	4½	33
252	90	56	5½	37
230	90	52	6	26
207	90	46	4½	34
253	80	63	4	36
209	70[2]	60	3¼	34

[1] Flaxedil solution contained 20 mg. [*o*-phenenyltris (oxyethylene)] -tris [triethyl ammonium iodide] per ml.
[2] Required the intravenous injection of 1 ml. of Tensilon to restore natural breathing.

safe range of the drug was determined on amounts of drug required per unit of body weight.

RESULTS AND DISCUSSION

The results of a series of Flaxedil injections given to four elk (Table 1) indicate that this compound can be used safely at the rate of 1 mg. per 3.5–5.5 lb. of body weight. These amounts cause initial paralysis in 3¼ to 9 minutes and duration of paralysis from 37 to 14 minutes.

The use of 1 ml. (20 mg.) of Flaxedil per 90 (± 20) lb. of body weight may make dosage calculation easier. This amount will give safe and effective curarization.

Doses of Metubine iodide to two elk indicated that the material was unsatisfactory. One animal was given 1 mg. per 120 lb. of body weight (1.8 mg. for 218 lb.). Paralysis occurred in 29 minutes and continued for another 62 minutes. The other animal received 1 mg. per 110 lb. of body weight (2.1 mg. for 250 lb.). Paralysis occurred in 18 minutes and continued for 1 hour and 52 minutes, when it was terminated by the intravenous administration of 1 ml. of Tensilon.

One elk was given *d*-tubocurarine chloride at the rate of 1 mg. per 75 lb. of body weight. Paralysis occurred in 22 minutes and lasted one hour and 12 minutes. One ml. of Tensilon was given to terminate paralysis.

As Crockford, *et al.* (1957) have pointed out, a satisfactory paralytic drug for use with a projectile in the field must have a quick paralytic effect to insure capture of the animal before it moves far from the collector. Metubine iodide and *d*-tubocurarine were considered to be unsatisfactory for the purposes required. Onset of paralysis was too slow. Duration of paralysis was considered to be too long.

The experimental results indicate that Flaxedil would be the most satisfactory of the three compounds tested. Flaxedil has a similar action to the other curare drugs. The action is on the striated muscle through the innervation of the striated fibers (Winter and Lehman, 1950). There is no hyperexcitable effect on the animal, as is usually experienced in other anesthetic and paralytic drugs. The quick renal elimination of Flaxedil and its paralytic effect are other desirable characteristics (Mushin, *et al.*, 1949). The only undesirable effect is the fact that all curare drugs will cause death by suffocation due to their action on the diaphragm and intercostal muscles.

The application of Flaxedil to elk in the field is a possibility. The increased use of projectile syringes will undoubtedly give an opportunity to evaluate it for field use.

All the curare drugs are very potent in their action. One must be able to judge animal weight quite accurately to use them. The use of an antagonist such as Tensilon would save casualties in case of over-curarization. A method of forced respiration would be useful in cases of extreme over-curarization. Flaxedil can be used to immobilize elk if it is used with moderate precaution. Metubine iodide and *d*-tubocurarine are not recommended for use in paralyzing elk.

SUMMARY

Flaxedil is a safe drug for paralysis of elk if it is used with moderate precaution. Personnel administering it must be able to judge body weight within ± 20 lb. for each 90 lb. of body weight. Metubine iodine and *d*-tubocurarine are not satisfactory paralytic drugs for elk. A dosage of 1 mg. of Flaxedil per 3.5:5.5 lb. of body weight [1 ml. Flaxedil (20 mg./ml.) per 90 (± 20) lb. of body weight] will give safe and satisfactory paralysis of elk.

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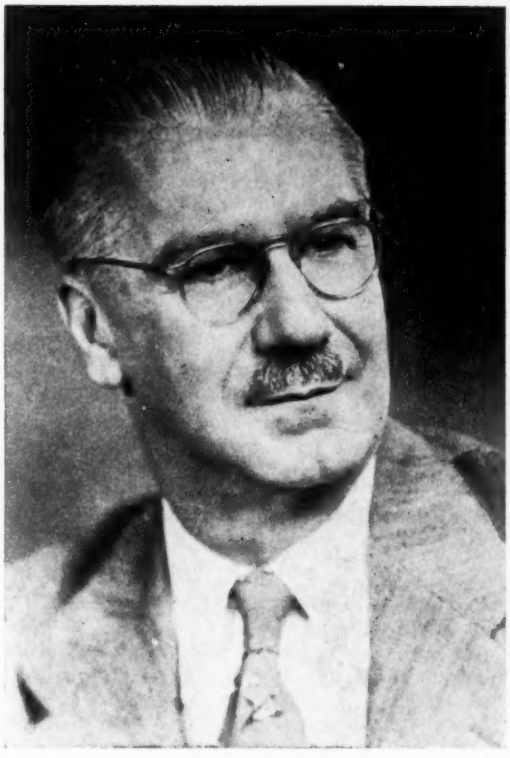
OBITUARIES

Pennoyer Francis English

1894–1958



P. F. English
Tenth President of The Wildlife Society

The wildlife profession, the Pennsylvania Cooperative Wildlife Research Unit, and The Pennsylvania State University lost one of their most distinguished colleagues with the death of Dr. P. F. English, Professor of Wildlife Management. Having suffered a mild heart attack at his office on September 17, 1958, Dr. English, after a satisfactory initial recovery at the Centre County Memorial Hospital, was sent home for a rest. Complications necessitated his return to the hospital where he died on October 8, 1958. He is survived by his wife, Elizabeth M., and his son, John William English, of West Palm Beach, Florida.

Born on February 21, 1894, in Farmington, Washington, Dr. English was named after a former governor of Oregon. He did not like his given names and was widely known to his friends simply as "P.F." His early schooling was received in the public schools of Salem, Oregon. In 1919, P.F. received his B.S. from Oregon State College where he developed a warm admiration for Howard M. Wight and where he remained as an Assistant in Zoology from 1919 to 1921. From 1921 to 1924 he was Assistant Professor of Biology at Texas A. and M. College. For 2 years he was Professor of Biology at St. Teresa College (Winona, Minnesota). His M.S. degree was granted in 1925 by Texas A. and M., to which he returned in 1926 as Associate Professor of Biology. During the summer of 1928 he did graduate work at the University of Chicago, and during the following summer he continued his graduate studies at Ohio State University.

In 1931, Wight induced P.F. to study for his doctorate at the University of Michigan. He remained there for 2 years working as a research fellow under Wight, carrying out field research with P. D. Dalke on the Williamston project, and receiving his Ph.D. in 1934. From 1933 to 1935, P.F. was on the staff of the Michigan Department of Conservation. His next 3 years were spent as Associate Professor in Wildlife Management at the University of Connecticut. In 1938, he was appointed Assistant Professor of Wildlife Management at The Pennsylvania State University, where he and the late Dr. Logan J. Bennett organized the Pennsylvania Cooperative Wildlife Research Unit for which Dr. English served as Assistant Unit Leader until his death. During the war years from 1943 to 1946, he was Acting Unit Leader, and from 1951 to 1953 he was Acting Head, Department of Zoology and Entomology, in addition to his teaching responsibilities.

P.F. was a charter member of The Wildlife Society, its Secretary from 1943 to 1946, and President from 1946 to 1947. Elected an Honorary Member in 1956, he was working on a history of the society at the time of his death. His other professional and honorary affiliations included the Society of American Mammalogists, Cooper Ornithological Club, Wilson Ornithological Club, American Ornithologists' Union, American Association of University Professors, Phi Sigma (biology), Sigma Xi (scientific), Gamma Sigma Delta (agricultural), and Xi Sigma Pi (forestry). From 1952 until the time of his death, Dr. English acted as faculty advisor to the social fraternity Phi Sigma Kappa.

Dr. English published approximately 50 papers and directed the graduate program of over 60 students. It is a humbling experience for one of these students to set down this man's biographical sketch. Impressive as this record is, I have the firm feeling that all who knew him admired, respected, and revered Doc for far more important reasons.

In a classroom or on a field trip his personal philosophy had an impact that carried far beyond the scope of his courses. He staked his professional reputation and ability as a teacher on the competence of his students. Over the years he stuck by the conviction that his students' accomplishments had not betrayed this trust.

Doc cherished personal friendships, and he worked to enrich them. As an individual he left little doubt as to where he stood on any issue. His stated position and principles were defended with vigor. If the occasion warranted, his comments could be brutally frank or have a caustic sting. However, his sincere personality and rare wit served to strengthen ties with old friends and enlarge his circle of personal acquaintances throughout North America.

Advice, counsel, and co-operation were extended to all who sought his help. Those who did gained from his experience. His standard of willing service left its mark on student, friend, and the profession he helped to found.

At the time of his death he was anticipating retirement at the end of the spring semester in 1959, so he had no illusions of indispensibility. In due time his work will continue, but there will never be another P.F. English.—ROBERT G. WINGARD.

MICHAEL GRZIMEK

1934–1959

In an air accident in East Africa on January 10, 1959, a young explorer, Michael Grzimek, lost his life. Despite his youth, he had already achieved an extraordinary eminence in the interests of Africa's wild animals.

Michael was born in Berlin on the 12th of April 1934. While still a young boy, he assisted his father, Dr. Bernhard Grzimek, in experiments with animals. He grew up at the Zoological Gardens in Frankfurt, and later studied natural science at the University of Frankfurt where—at the time of his death—he was working for his doctor's degree.

As a schoolboy, Michael became interested in film-making. He produced several documentary films about animals, which were awarded certificates of merit. At the age of 16, he accompanied his father on an expedition into French West Africa. There his father found it necessary to return suddenly to Germany, leaving young Michael behind to attend to the transportation of about 200 animals. He brought them from the interior to the coast and embarked them on a small French steamer bound for Hamburg, bringing all of them safely to the Frankfurt Zoo. In the years that followed, father and son became inseparable companions on journeys in Africa.

Becoming aware of, and deeply perturbed by, the rapidly decreasing numbers of wild animals in Africa and the threat of their extinction, Grzimek produced a full-length documentary feature film in color, "No Room for Wild Animals," based on his father's book of the same title. This production involved him in heavy personal sacrifices and the strain of raising the necessary finances. At the Berlin Film Festival in 1956, where the competition included Walt Disney's film, "The African Lion," Michael's film was given First Prize and two Golden Bear awards. This film has now appeared in 63 countries, arousing world public interest in retaining at least the last animal sanctuaries in the national parks and game preserves of Africa.

Michael used his share of the film revenues not for himself but to further animal welfare. He advanced large sums to the Frankfurt Zoo, financed a scientific expedition to the Garamba National Park in the Belgian Congo, and, in particular, he offered the major part of his newly acquired wealth to the British Administration in Tanganyika for the purpose of acquiring additional land for the extension of the game preserves. However, Lt.-Col. P. G. Molloy, the Director of Tanganyika National Parks, suggested that it would be preferable for Michael to use the money to make a faunal survey of the Serengeti National Park and to carry out research on the migrations of the last remaining big herds of African plains game. Thus, in the light of information obtained, revisions of the present boundaries of the National Park could be made and propaganda created for the preservation of the animals.

Before this investigation was undertaken, very little was known about the range requirements and the migratory cycle of the big herds of gnus, zebras, giraffes, gazelles, etc., in this great region. In fact, nobody knew for certain whether new boundaries for the Serengeti National Park (and other national parks in Africa), which were being proposed more or less arbitrarily, would in fact enable the animals to find sufficient food the whole year round once the surrounding territory had been given over to settlement and industrial development. It had never been possible to discover the directional migrations of these herds during the different seasons of the year, because of the vastness of the territory, lack of roads, and the impossibility of human travel in most of the territory during the long rainy season. Other basic faunal questions centered on (1) the relation of the Ngorongoro Crater game to this annual cycle and (2) the actual numbers of game, species by species, in the Park.

Michael Grzimek realized that the only way to discover the true facts in relation to these vast areas was to make an aerial survey with the aid of a specially designed aircraft. He and his father learned to fly and flew to Africa in a small plane designed to fly at exceptionally low speed and low altitude, and capable of landing on rough ground. Shunning personal publicity, for many months they flew day after day over this huge territory, according to a carefully planned system. They covered the whole area a small strip at a time, taking photographs with geographical cameras and making a census of the plains game actually existing there. They tracked the migrations of the big herds during every month of the year and recorded this information on maps. Simultaneously, Michael was also able to carry out a botanical survey by making over

MICHAEL GRZIMEK

a hundred landings and taking samples from every part of the Serengeti. This knowledge has led to a better understanding of the reasons for the migrations of the big herds, particularly after Michael had taken and chemically examined hundreds of samples of the soil. He was then able to prepare a botanical map of the Serengeti involving dozens of plants, some of which had been newly discovered.

To identify the herds under observation during their migrations, several dozens of animals were clearly marked with ear clips and with colored wads of nylon material, so that they could then be easily seen from the air or from the ground with the aid of field glasses. To catch and mark them, the animals were injected with a paralytic compound by means of special equipment. During one of these incidents, Michael was severely wounded in the neck and flown by his father to the hospital at Lake Victoria, where an operation was performed.

Michael Grzimek's research work has yielded quite startling and unexpected results and knowledge, which are of value not only as regards the Serengeti, but also elsewhere. One very significant and somewhat surprising result of his investigations was the discovery that the large mammals—almost half a million—dwell many months of each year *outside* the proposed new boundaries of the National Park. His new approach and methods, designed to make the continuation of life and existence of the herds possible in such large territories, are of the greatest importance to the whole of Africa and other overseas national parks. As Lt.-Col. Molloy has stated, "In Michael Grzimek the cause of animal protection in Africa has lost one of its most ardent and experienced supporters."

Having just completed his program of research in the Serengeti and intending to return to Germany within a few days, Michael was on a flight to pick up an English and a German colleague when his plane crashed. The accident, brought about by that everyday hazard of African aviation, collision with a vulture, was witnessed by natives who that very same night brought the body of the young explorer to his father. Michael was buried, according to a wish he had once expressed, on the rim of the Ngorongoro Crater, at an altitude of approximately 5,500 feet, where the climate is eternally spring-like. The British Administration asked in the newspapers for donations to a *Michael Grzimek Memorial Fund*. As the black and European population of Tanganyika contributed very generously, the government will build a laboratory for scientists in the Serengeti and erect a boulder which will bear the following inscription:

MICHAEL GRZIMEK
12.4.1934–10.1.1959
He gave all he possessed
including his life
for the wild animals of Africa

Michael was married and leaves behind a small son of three years, Stephan. His wife, formerly Erika Schoof, knew him from childhood and together they became interested in photography.

This young man led a life that might well be envied by millions of young people. He had the opportunity during his youth to go on expeditions, to see the beauties of the tropics and to experience adventure and danger. His achievement was that he emerged from the shadow of his well-known father to become a personality in his own right and to make his own mark. He remained throughout cheerful, modest, industrious, and content. It seemed that he was beloved by the gods who, according to a saying of the ancient Greeks, take early whom they love.—HERMANN GIMBEL.

W. KENNETH THOMPSON

1917–1958

With the recent death of Ken Thompson, Montana and the nation have lost a stalwart and active worker in the field of wildlife conservation.

W. Kenneth Thompson was born July 14, 1917, at Niarada in western Montana. Even in his boyhood, Ken indicated a keen interest in the out-of-doors. He set an unusually fine record in the scouting program in Montana by attaining the rank

of Eagle Scout and continuing his interest as a Junior Leader in that activity. He attended Montana schools and in 1941 graduated from the State University in the first class in wildlife technology set up by that institution.

In this same year he entered the employ of the Montana Fish and Game Department as a field biologist. With the exception of time out for active duty in the Navy during World War II, Ken worked continuously with the Department until his death. He was Assistant Director of the Wildlife Restoration Division during the early years of Montana's Pittman-Robertson program. Ken was chosen Chief of the newly formed Division of Information and Education for the Montana Fish and Game Department in 1951. He held this position until his untimely death on December 16, 1958, from a brain tumor.

Although a native of Montana, Ken's conservation interests went far beyond the borders of his home state. He was an active member of the Wildlife Society. His love of wilderness was a strong motivating force throughout his life. He was always in the forefront of any controversy that threatened these areas.

Although extremely busy with his conservation program, Ken always found time to help young people enjoy the out-of-doors. He was particularly active in scouting and aided much in the development of conservation programs for the 4-H clubs and Future Farmers of America. He was instrumental in the development of an important Montana teen-age conservation program. Ken was an active member of the Outdoor Writers of America and was secretary-treasurer of the American Association for Conservation Information at the time of his death.

In addition to his wife, Hallie, and four children, he is survived by his parents in Missoula.

I am sure that all of us who had the privilege of knowing Ken Thompson through the years gained something very important from his clean, zestful philosophy of life. We will always remember his ready smile and helping hand. The quiet places far back in remote wilderness will remind us of him because that was the kind of country he most enjoyed.—ROBERT F. COONEY.

BOOK REVIEWS

Statistics—A New Approach. By W. Allen Wallis and Harry V. Roberts. The Free Press, Glencoe, Illinois. 1956. xxxviii+646pp. $6.00.

Statistical Methods Applied to Experiments in Agriculture and Biology. 5th Edition. By George W. Snedecor, with Chapter 17 on Sampling by William G. Cochran. The Iowa State College Press, Ames, Iowa. 1956. xiii+534pp. $7.50.

Experimental Design Theory and Application. By Walter T. Federer. The Macmillan Company, New York. 1955. xix+544+47pp. $11.00.

These are three very different books, but they are alike in the obvious dedication of the authors, and the massive effort spent in trying to help the nonmathematician apply statistical reasoning. In brief, Wallis and Roberts discuss the nature of statistical reasoning, using statistical techniques only as necessary to illustrate their presentation. Snedecor directs his text toward application of statistical techniques and interpretation of the results, especially in agricultural experimentation, with emphasis on the analysis of variance. Federer, in a sense, continues farther in the same direction, restricting his attention to a detailed survey of that vast proliferation of analysis-of-variance methods used in agriculture. Each book presents a wealth of good examples, and it is only by working over and understanding these that the biologist can reach the stage of being able to generalize from other fields to the problems in his own area. The situation is unpleasantly reminiscent of Hess's ducks, for learning seems to proceed not in the ratio to amount of quacking, but according to the effort expended.

It is precisely to this problem of generalization that Wallis and Roberts direct their efforts. Their "new approach" is to expound, in lucid and intelligent detail, a number of instances of applied statistics and to present the student with a great number of other examples in outline. This approach, while exactly as new as good teaching, is a welcome relief from that which seems to confuse mathematical generality with generalization of ideas. But either way, the student must still transfer the ideas over to his own field of application.

In the first half of their book, Wallis and Roberts discuss the nature of statistics and its use and misuse, along with the concepts of average, variability, and association. The variety and range of examples presented is more than impressive. Their ready humor is never far below the surface of the discussion, and has so governed the selection of examples that this is now a prime source of classroom and after-dinner anecdotes, as well as a teaching aid.

The third quarter of the book covers most of the content of the usual beginning course (probability, distributions, tests and decision procedures, estimations, and confidence limits), leaving the final five chapters for special topics. Here they continue to study a subject-matter problem first, then discuss a statistical solution. Nonparametric methods are presented early, and the final chapter is devoted to them, with some 12 pages on uses of binomial probability paper. The authors defend their action,

but it is still surprising that they exclude the *t*, *F*, and *chi-square* tests. At appropriate places, a normal approximation method is substituted for each of these. This meets their teaching needs, but I fear that it is a serious deficiency for the biologist who may need an explanation of one of these tests as used in some paper in his field. Chiefly for this reason, I feel that this excellent book will not satisfy a field biologist as a single reference on statistical methods. On the other hand, I think that for such a person this is the most understandable discussion available on the basic theory of modern applied statistics.

Snedecor's *Statistical Methods* has been, in various editions, a standard work for over 20 years. Inclusion of new material and revision of old is the reason for including it here, as well as the wish to compare it with the other books. Entirely new, and very useful, is the chapter on sampling by William G. Cochran; every sentence, almost, is directly applicable today in field biology. In the rest of the book, emphasis continues on the testing for differences by analysis-of-variance methods, but many other techniques are presented. Professor Snedecor has brought up to date the treatment of several subjects, and now includes among other topics a multiple-range test, a few nonparametric tests, and some discussion of Type II error and power.

The unique value of the book continues, as formerly, to be its profound understanding of biological problems and their useful solution. It is clear, however, that *Statistical Methods* has not been rewritten as a whole, and the lines of patching show more clearly than ever. The previous uneven quality of exposition continues; we might not see this so clearly were not some parts of such high excellence. Regardless of these faults, this book still leads in its field, and many biologists will use it as a sole, or principal, reference. They will wish to acquire this edition for the new material in it.

Experimental Design, by Federer, is a specialized treatment of a single but important part of modern statistics, the analysis of variance, as developed in agricultural research. One should realize that, since 1935 when R. A. Fisher published *The Design of Experiments*, any book with a similar title has had to do almost exclusively with the analysis of variance. Thus, one should not expect to find here anything but very general help in planning experiments which must use other statistical tools. Within its considerable field, however, this is a most useful work.

Field biologists increasingly are using the analysis of variance in its simplest forms, but there seem to be very few situations where the most complex designs have been useful. One reason is that rarely in field biology does one encounter the principal problems of farm crops, the testing of many varieties, and of many controllable environmental factors; hence, incomplete block designs have not yet been needed. Second, we often are not confident that our data meet the considerable assumptions of the method. But probably the most important reason is simply that those designs that might be useful are largely unknown to the biologist. The present book should be helpful for the worker of some statistical sophistication.

The first two (of 16) chapters discuss general principles, concepts, and tools, and the third chapter considers the plot technique. Thus far, the material is highly useful to anyone using the analysis of variance in any form, especially so is a section comparing several "multiple range" tests, and another on transformations. Various designs are next considered, with chapters on completely randomized, randomized block, and latin square designs, four chapters on factorial and three on incomplete block designs, one on balanced and one on other designs, with a final chapter on covariance in various application. At the present, I would guess that something over half of the book is applicable in field biology, either directly or potentially.

This book reflects the author's great knowledge of this field. For each design the practical and the statistical aspects are discussed, then often summarized as advantages and disadvantages compared to other designs. Some hundreds of references are included, especially to cover issues aside from the main lines of thought, and the section of problems in the back has a lightly annotated set of references for each design—a helpful method for providing further examples. The prose is not always easy to read. Statistical notation is much used, because it is necessary, but this fact will not discourage a serious student.

This is a highly useful book, in my experience. Persons with more than passing interest in experimental field biology should examine it with care, and those specializing in this area will probably need to use it. It is not a book for the beginner.

In summary, then, Wallis and Roberts provide a modern book that has something to offer biologists of almost any level of experience, but it is not a handbook of methods. Snedecor's book still comes closest to providing that single reference on methods that biologists seek, but that does not exist. Federer offers the key to a restricted part of experimental biology, where there is promise of future development in our field.—DON W. HAYNE, Institute for Fisheries Research, Ann Arbor, Michigan.

Perspectives on Conservation. Edited by Henry Jarrett. The Johns Hopkins Press, Baltimore. 1958. xii+260pp. $5.00.

The year 1958 had a special significance for conservationists, since it marked the 50th anniversary of President Theodore Roosevelt's first Governors' Conference to consider resource problems. *Perspectives on Conservation* is a fitting memorial for this anniversary. The volume grew out of the 1958 Forum on Conservation sponsored by Resources for the Future, Inc. At each program an expert in a particular area of resource conservation presented

the principal paper, which was in turn the subject of several short critical papers by commentators. The book follows this general outline and as a result gives the reader a feeling of participating in the forums. The method of presentation, however, also has the disadvantage of being rather uneven and undirected. The lack of direction is particularly evident in certain sections; for instance, Minor S. Jameson's comments on Edward S. Mason's paper on "The Political Economy of Resource Use" are mainly a defense of the petroleum industry, with which Jameson is closely connected. Nevertheless, the volume provides a stimulating look at the conservation movement.

The principal papers are Griffith's "Main Lines of Thought and Action," Nolan's "The Inexhaustible Resource of Technology," Galbraith's "How Much Should a Country Consume?" Gulick's "The City's Challenge in Resource Use," Mason's "The Political Economy of Resource Use," and White's "Broader Bases for Choice: The Next Key Move." The short papers are generally excellent, particularly Hart's discussion of the changing context of the problems of conservation, but the commentaries largely deal in more detail with one aspect of the principal paper.

Griffith presents an interesting political history of conservation from 1908 to 1958, which traces in some detail the contributing influences in the development of self-conscious conservation. Throughout the last 50 years certain persistent trends have continued to influence the conservation movement. Griffith discusses the dilemma between present use and future use, public or private ownership and development, and political regionalism. It is unfortunate that in the first series of essays the writers make no attempt to define their subject; in fact, Dana congratulates Griffith on avoiding a definition of conservation. This reviewer feels that it is somewhat difficult to accept the development and conclusions of a subject that the writers cannot define. As President Taft said: "There are a great many people in favor of conservation, no matter what it means."

Nolan, a geologist, presents an interesting thesis, i.e., that technology is a resource that can be substituted for other resources. This is no new idea, of course, but his emphasis on the dangers of inadequate or belated utilization of our intellectual resources is worthy of attention. Too often the emphasis in the conservation movement has been on the fear of exhaustion of resources; rather, it is now time to accept Nolan's optimistic point that the human mind is an unlimited resource and that by proper training and use of the minds of our people the problems of the future may be overcome.

Galbraith, an economist, suggests that the conservationist has too often been guilty of illogical thinking and "selective myopia." Although Galbraith's Law ("the conservationist is a man who concerns himself with the beauties of nature in roughly inverse proportion to the number of people who can enjoy them") certainly overstates the point, there has been a traditional selectivity, among conservationists and others, in their approach to consumption of resources. The crux of this problem may be that, while we are greatly concerned about the supply of resources, we ignore the "appetite" for consumption of resources. Indeed, it has been suggested by economists that greater appetite or consumption is absolutely necessary for our continued economic growth. In general, conservation thinking has not yet critically examined this traditional economic theory and placed proper emphasis on the need to curb our national appetite for consumption.

Gulick deals with the tremendous impact of urbanization upon natural resource use. He proposes that, since urbanization will continue—in fact, ". . . in the next decade, at current rates, the *added* urbanized acreage will be as large as the total land area of Rhode Island, Connecticut, New Jersey, and Delaware put together"—we must (1) develop a better understanding of the new patterns of urban needs, (2) develop in urban man a new awareness of his relation to nature, and (3) convince urban man to develop a system of life that depends more on renewable than on exhaustible resources. Gulick suggests that urban man's problem is that he is becoming less sensitive to the ecosystem of which he is a dependent part and, therefore, less capable of taking logical political and personal action to insure proper use of natural resources.

Mason defines conservation as the avoidance of (a) waste in natural-resource use or (b) a faulty time distribution of the rate of use of a natural resource. This definition excludes many areas of interest to the conservation movement—such as preservation of wilderness areas—but provides the basis for Mason's discussion of the relation of price to resources and the variation in costs and benefits of resource development which may justify public intervention in the resource fields.

In the final essay, White, a geographer, discusses the need for a new and effective conservation program. Few of our organizational innovations in response to resource problems have been fresh and new, and almost none show any promise of being useful in light of the tremendous problems facing us in the future. According to White, the TVA project is our one example of successful innovation; the assessment of other multiple-resource programs will require even more radical governmental organization and programming. In this connection, White discusses four problems: (1) why states have generally failed to exercise a strong hand in resource conservation and development, (2) why consolidation of splintered federal agencies dealing with conservation has been prevented, (3) why formal co-ordination among federal and federal–state agencies has been usually meager, and (4) why partnership between federal and private enterprise has been largely fictitional and often exploitive. We

may expect little improvement in these four problem areas until the national aim or goal of resource management is determined. White points out that it is unreasonable to expect a satisfactory conservation program to develop from the existing federal, state, or private agencies, since these all have a limited view and cannot see conservation in its entirety. This reviewer suggests that the aim of national resource management could best be achieved by consolidation of agencies concerned with resource management into a single department within the federal government, which would be able to evaluate civilian and military resource requirements and which could direct the exploitation and development of natural resources toward meeting these national requirements.

It is encouraging to see professionals in such diverse fields as economics, sociology, public administration, tax and finance, engineering, etc., directing their attention to the field of conservation. It will be only through a synthesis of the thought of these professionals concerned with man and his economic and sociological problems with that of the ecologist and other biologists that a coherent program will be developed within the conservation movement. Conservation has been dominated too long by the specialists in biology who, ignoring the cultural and economic propensities of man, predict a dire future for the human race. This pessimistic view, which may be justified in some instances, must be tempered with the optimism of the physical scientist, technologist, and sociologist if the conservation movement is to continue to advance during the next 50 years. *Perspectives on Conservation* represents a desirable integration of those diverse viewpoints and, as such, provides a point of departure for the conservation movement of the future.—FRANK B. GOLLEY, Department of Zoology, University of Georgia, Athens, Georgia.

The Birds of Alaska. By Ira N. Gabrielson and Frederick C. Lincoln. The Stackpole Company, Harrisburg, Pennsylvania, and Wildlife Management Institute, Washington, D.C. 1959. 922pp., 12 illus. $15.00.

At long last this much-awaited volume on Alaskan birds has been published. The authors labored for over 15 years to prepare this initial treatise covering the avifauna of the vast area of Alaska. Until now it has been practically impossible to find out exactly which birds have been recorded in Alaska, and when and where they were recorded; now we have this information well documented and presented in a single volume—a volume that will be a standard reference for years to come, and one that will be used by both amateur and professional biologists alike.

The main work on the manuscript for this book was completed in 1956. In many ways, however, it is more current than that. Published almost coincidentally with the granting of Alaska Statehood, one is pleased to see Alaska referred to in most instances as a state rather than a territory. The appendix brings the species list up-to-date as of June 25, 1958. With a few exceptions, the scientific names are those used in the fifth edition of the American Ornithologists' Union *Check-list*. Unfortunately, however, many of the common names differ from those of the *Check-list*.

The introductory portion of the book includes a rather complete and well-documented "History of Alaskan Ornithology," beginning with the Russians in 1741; and a disappointing and poorly presented discussion of "Alaskan Ecological Zones" based on C. H. Merriam's Life Zones and on the Alaskan faunal districts used by E. W. Nelson in 1887. Also included are brief discussions on "Some Interesting Aspects of Alaskan Ornithology," "Migration," "Introduced Game Birds," and a labeled plate on the "Topography of a Bird," which undoubtedly will be of use to the lay reader in understanding the species descriptions.

Following the main body of the text is a "Hypothetical List" including 21 species or subspecies; a valuable "Gazetteer" compiled by Myra A. Putnam; an extensive "Bibliography and References"; an appendix listing seven "recently" added species or subspecies; and a species index, including both common and scientific names.

Ten colored plates, each portraying 4–10 species, add greatly to the work. Appropriately, they were painted for this publication by E. R. Kalmbach and O. J. Murie, both former colleagues of the authors in the U.S. Biological Survey and, later, the U.S. Fish and Wildlife Service. Unfortunately, in several plates of my copy, the register of the printed color overlays is poor. These plates, with the exception of the figure on the topography of a bird and a small outline map of Alaska, are the only illustrations in the book.

The main body of the text (774 pages) treats all naturally occurring species of birds that have been recorded in Alaska. Each account includes a detailed description of each species (sex, age, and seasonal variations), adapted from various other authors; and, where available, descriptions of the nest and eggs. A summary of the general range of the species is given, based on the fifth edition of the *Check-list*, and detailed data on the range within Alaska (including some information on migration) are given. A section on "Haunts and Habits" concludes most accounts; the section includes a miscellany of information, varying from species to species, on field identification and species differentiation, notes on voice, food, habitat, behavior, nesting activities, etc. It is often an interesting section, but it is difficult to use when one is searching for specific information.

The greatest contributions of this work are the detailed accounts of the ranges in Alaska of each species, and the supporting, exhaustive bibliography. One of the stated objectives of the authors was to "compile a bibliography of Alaskan ornithol-

ogy that would be as complete as possible," and in this they have been most successful. The bibliography, which was closed on December 31, 1956, is briefly annotated, and includes, in addition to the usual citations of published materials, references to a number of unpublished reports, manuscripts, and theses. Moreover, in compiling the data for the comprehensive accounts of species ranges, the authors have done a commendable job in summarizing such unpublished information as is available in many government in-service publications, in the geographic distribution files of the U.S. Fish and Wildlife Service, and in letters from various observers. Throughout, the authors have carefully noted their informational sources and have been generous in their specific acknowledgments to contributors. These authoritative summaries clearly delineate the status of Alaskan ornithology today.

Unfortunately, the book suffers somewhat from what one might call "absentee authorism." Lincoln has apparently never visited Alaska, and Gabrielson, while he has been here seven times, has had to carry on most of his ornithological activities as a side line to other duties. Most of his Alaskan experiences are limited to the coastal areas, especially from southeastern Alaska to Bristol Bay. Only three times has he visited the vast interior, apparently each time for less than a week, and only once during the breeding season. Lacking personal observations by the authors, and lacking published information, the material on the interior is weak. The book states, for instance, that there are no nesting records of the Hammond's flycatcher in Alaska and that ". . . summer records indicate that it barely crosses the Alaska boundary . . . ." To the contrary, however, it is one of the most common resident flycatchers in the immediate vicinity of Fairbanks during the summer.

In places I find the book difficult to use because of inconsistencies in the presentation of the species accounts, especially in the treatment of ranges. In the discussion of subspecies, for instance, sometimes "Range in Alaska" is included separately under each subspecies account (see *Branta canadensis, Anas crecca, Tringa solitaria*), but more often the descriptions for the separate subspecies are awkwardly combined under "Range in Alaska" for the entire species. Many of the topic headings lack uniformity: In the accounts of waterfowl, "Status in Alaska" often replaces "Range in Alaska," while only "Range" is used in other accounts (see pages 117, 306, 307, 311). On pages 119 and 225 "Range in Alaska" is printed in bold lower case type instead of the usual bold capitals. The species range is completely omitted from the discussions under willow ptarmigan.

The book has an unfortunate number of minor errors, both factual and printing. For example, several employees of the U.S. Fish and Wildlife Service in Alaska are erroneously cited as belonging to the Alaska Game Commission. A specimen of ring-necked duck is cited as collected at Minto Lakes, whereas it was collected at Ace Lake. On page 168, Minto Lakes is listed as 30 miles west of Fairbanks, whereas in the Gazetteer on page 844 it is listed as 50 miles west of Fairbanks. In a quotation from Bent on page 358, the quote is closed a sentence too early. In this same passage, "know" is misspelled. On page 28 typographical errors result in the wrong initials for P. E. K. Shepherd and a misspelling of Kessel. Kotzebue is spelled incorrectly on page 144. And I feel certain that the vegetable matter in the stomach of a "few" snow buntings was not meant to be given in the accuracy indicated by 70.74 per cent on page 823.

These errors and oversights, however, scarcely detract from the outstanding contribution of this work. It is a "must" for all persons seriously interested in the avifauna of Alaska and the North. It points out many conspicuous gaps in our present knowledge of Alaskan birds and will serve as a summary of today's knowledge upon which to build in the future. The authors are to be congratulated on the completion of this authoritative and valuable volume.—BRINA KESSEL, Department of Biological Science, University of Alaska, College, Alaska.

Seals, Sea Lions, and Walruses. A Review of the Pinnipedia. By Victor B. Scheffer. Stanford University Press, Stanford, California. 1958. x + 179pp. $5.00.

It is nearly 80 years since the publication of J. A. Allen's work on North American pinnipeds and some 50 years since a full systematic account of the group was published. This long-needed book provides an up-to-date review of the Pinnipedia, and Dr. Scheffer is to be congratulated on including such a wealth of information. To present this very varied information within the compass of about 150 pages of text is in itself no mean feat, but the author also gives a clear, balanced, and readable account of these interesting animals.

With the exception of an introductory chapter, in which the biology of pinnipeds and their adaptations to the aquatic environment are briefly dealt with, the book is primarily concerned with the evolution, distribution, and systematics of the three families that make up the group.

Chapter 1 describes the general adaptations, size, form, locomotion, special senses, nutrition, salt balance, respiration, diving adaptations, and other related aspects of anatomy and physiology. There are necessarily brief accounts of reproduction, early growth, and factors in mortality. This chapter introduces the living pinniped and provides a useful background for the rest of the book.

Chapter 2 deals with the evolution of the order and its three families. The author favors the view that the pinnipeds and fissipeds have a common ancestry but feels that, in view of their several unique characters, the pinnipeds deserve recognition as a separate order. He expresses the opinion that of the three families the Phocidae are most

specialized, the Otariidae the least specialized, and the Odobenidae intermediate, but closer to the otariids. In this view he disagrees with Howell, but probably has the support of most current workers on the group.

In Chapter 3 the author suggests that existing genera, species, and subspecies are the result of evolution in four stages, namely invasion, geographical isolation, dispersion, and stabilization. The early populations were probably small, not sociable or migratory, and, in advancing into the sea, they probably met with little competition. Adaptive radiation of these populations occurred along separate coastlines and, with increasing specialization and isolation, the generic stocks deviated from each other. At a much later stage, with increasingly efficient adaptation to the environment, dispersion and intermingling occurred, and members of different genera now breed side by side in complete reproductive isolation. Finally, the author suggests that pinnipeds were influenced by three factors that slowed down the rate of evolution and brought relative stability; these were increased sociability, longevity, and mobility. This history is reflected in current taxonomic arrangements which show many genera, but few species.

These short chapters lead up to the main part of the book, which is concerned with the systematics of the Pinnipedia (Chapters 4 and 5). In general the author adopts Simpson's arrangement as regards supergeneric groups, but adds the superfamilies Otarioidea and Phocoidea, and also the subfamilies Otariinae and Arctocephalinae, and several tribes within the Phocidae. The subfamily Monachinae is restored.

The author has traveled widely to view type specimens in museums and has made a special effort to trace the original literature. For each species he gives references to the literature, the more important synonyms, description of the "type" material, type locality, geographical range, and vernacular names. Where possible, estimates of the population sizes are given, this being the basis for the estimated world populations of some 3,000,000–4,000,000 Otariids, 45,000–90,000 walrus, and 11,000,000–22,000,000 Phocids.

The genus is perhaps the most difficult taxonomic grouping to define, and the author seeks to get around this by listing certain attributes of genera and illustrating them by examples. He divides the Pinnipedia into 20 genera, only five of which contain more than one species. Dr. Scheffer suggests that, at any selected place in the marine environment, there are too few ecological niches to permit the co-existence of two pinniped forms that are as closely related as species of the same genus. He therefore allocates certain closely related northern seals to the four genera, *Phoca*, *Pusa*, *Histriophoca*, and *Pagophilus*. This thesis does not, however, apply to the last two forms whose respective ranges of distribution are the North Pacific and North Atlantic oceans; the reasons for according them generic distinction might, with advantage, have been made more clear.

There is a helpful discussion of the relationships of the southern fur seals. The author restores the subfamily Monachinae to include the tribes Monachini and Lobodontini, a useful arrangement. He suggests that new important concentrations of seals will not be discovered in the Antarctic, overlooking the fact that few ships have been in the area at a time when concentrations of crabeater seals may be expected, and in the reviewer's opinion the population of crabeater seals is greatly underestimated. The seasonal distribution of harp seals in the North Atlantic illustrates this point. The Ross seal is not absent from eastern longitudes; there is, for instance, a long-standing record of a group of seven seen at longitude 90° E. by the Australian National Antarctic Research Expedition, and other records show that the distribution is circumpolar. A reference to the authority for the statement about the neonatal coat of this species would be useful.

These are minor criticisms of a book that will be most useful to specialists and to mammalogists and zoologists in general. Specialists will appreciate the synoptic key to the genera, and the 32 pages of plates are of a high standard, although one of them (Plate 27) is reproduced upside down. There is a valuable selected bibliography of some 500 references, including a number as recent as 1957.—R. M. LAWS, National Institute of Oceanography, Wormley, Godalming, Surrey, United Kingdom.

The Wood Rats of Colorado: Distribution and Ecology. By Robert B. Finley, Jr. University of Kansas Publications, Museum of Natural History, Lawrence. 1958. Vol. 10, No. 6, pp. 213–552; 82 illus., including 6 distribution maps and 74 half tones; 35 tables in text.

This monograph is concerned with the distribution of six species of wood rat (genus *Neotoma*) in Colorado. In the author's words, his study deals with "the local and geographic extent of their ranges, the factors limiting their spread, and the interspecific relationships permitting overlap of their ranges." Aware that in the time available he could not obtain complete knowledge of the ecology of even one species, he chose to concentrate on the aspects of life history that he considers have the most direct influence on the distribution of wood rats, namely local habitat, shelter, and food. Most of his information was secured by detailed examination of dens at which wood rats were captured, with special attention to localities in which the ranges of two or more species overlap.

Colorado has a wide diversity of topography, climate, and vegetational types. While no species of wood rat occurs throughout the state, almost every part is inhabited by one or more species. Here, then, are ample opportunities for studying the distribution and ecology of these animals. However,

Finley points out the need for studies comparable to his own in other parts of the range of *Neotoma* if, for example, certain taxonomic relationships are to be clarified and the reasons for geographic differences in denning habits determined.

Believing in the necessity of a sound taxonomic background against which to organize ecological data, Finley devotes approximately one-third of his report to general and taxonomic characters and variations of the genus and to systematic accounts of the 6 species and 12 subspecies. Detailed ecological accounts of the species and subspecies comprise about one-half of the paper. In addition to analytical descriptions of habitat, den, and food of each kind of wood rat, information is given on storage, reproduction and young, molts, and parasites—and for three species, injuries and disease.

There is some duplication of detailed information concerning kinds of plants available within 100 ft. of dens and those used as food by the several subspecies of wood rats. However, the author's presentation of these data relative (1) to each of many representative dens and (2) to each subspecies strikes me as potentially useful to subsequent workers. In an effort to present a "clearer picture of shelter requirements and denning behavior," Finley includes descriptions of at least 63 of the many dens and houses studied. Such detailed reporting is justifiable because of the wide variety of shelter conditions that satisfy the needs of wood rats, and the various ways in which individual rats use the available resources. I believe that those persons engaged in serious research can profit by published records of representative minutiae. Probably least significant in this paper are the several tabulations of materials accumulated at dens.

Environmental factors apparently most important in limiting the distribution of one or more species of wood rat in Colorado are: (1) low temperatures, (2) rivers as barriers, (3) absence of suitable rock outcrops providing den shelter, and (4) absence of suitable cactus or shrubs for house support.

Finley concludes that: "Suitable den shelter is the environmental resource most frequently fully exploited, hence most limiting," and that "competition for den sites may be expected to exist between two or more kinds of wood rats to the extent that each requires the same kind of den shelter." He sees this competition as the force that has brought about "divergent adaptation to different kinds of shelter," a pattern he considers important in the evolution of species of wood rats, with sympatry one of the results.

After having recognized suitable den shelter as a limiting factor, the author introduces a slight discrepancy by stating that competition for den shelter "is an important factor limiting populations of wood rats" (p. 546). Competition may, indeed, result in one species of wood rat replacing another or forcing it to occupy other and perhaps less desirable space. However, it might be more instructive to look upon den shelter as the limiting factor, and competition as an interaction that intensifies or otherwise alters the effect of the limiting factor.

Be that as it may, Finley has made a substantial contribution to knowledge about wood rats in keeping with much of the work on American mammals that is being done at the University of Kansas. The paper has scholarly proportions. It is obvious that such a report as this is possible only by virtue of innumerable hours in the field, constant and patient attention to details, and imagination enough to exploit many possible approaches to the problem under a variety of circumstances. Although, as the author mentions, "some of the attributes of wood rats make these rodents especially suited for biogeographic and evolutionary studies," comparably intensive studies could profitably be directed at many other vertebrates. Stimuli toward further research inhere in the speculative nature of his discussion—and that is as it should be.—EDSON FICHTER, Idaho State College, Pocatello, Idaho.

The Prairie Grouse of Michigan. By G. A. Ammann. Michigan Department of Conservation, Lansing, Michigan. Unnumbered Technical Bulletin. 1957. 200pp.

This attractive book was selected jointly with *A Guide to Prairie Chicken Management* by F. N. Hamerstrom, Jr., *et al.*, as the outstanding wildlife publication of 1957 by The Wildlife Society (J. Wildl. Mgmt., 22(3):298). It is an excellent presentation of the results of Michigan Federal Aid Projects 5-R, 37-R, and 70-R. It is paper bound and profusely illustrated with 53 figures, including maps, photographs, aerial photographs, and graphs. There are, in addition, 7 unnumbered photos and one unnumbered map. There is a colored frontispiece by Schafer, and color is used in headings and illustrations.

A foreword by H. D. Ruhl is followed by an introduction that includes purpose and scope of the investigations, identification of the "prairie grouse" as the greater prairie chicken (*Tympanuchus cupido pinnatus*) and the prairie sharptailed grouse (*Pedioecetes phasianellus campestris*), and a brief history of the investigations.

The Prairie Grouse of Michigan reviews years of research and outlines practical management measures for these species. As Ruhl says in the foreword, ". . . if man decides that the open lands of the north and their special creatures are a part of the Michigan heritage . . . the tools exist to keep them." A basic philosophy of the book is well put on page 137 as follows: "In this instance the job facing management is to keep the prairie grouse numerous enough to hunt. If that proves to be impractical, management has the responsibility of preserving the species for their ecological and aesthetic values." Such a viewpoint is indeed to be commended.

Chapter 1 gives a thorough history of prairie chickens and sharptails in Michigan with the inter-

esting interactions of man, habitat, and birds. In Chapter 2 the sharp-tailed grouse stocking program is considered from many angles: history, summary of releases, recoveries, fate of released birds, analysis of releases as related to release sites, and recommendations for further stocking. Of considerable practical importance and theoretical interest is the observation that releases made on the cyclic rise were more successful than others. Under the heading of "Habitat Preferences" in Chapter 3, cover, soil, and physical conditions that make up good grouse habitat are discussed. Consideration is also given to special habitat requirements. A schematic optimum summer sharptail range is presented. This important chapter takes up over a fifth of the book.

Among factors affecting productivity considered in Chapter 4 are the following: sex ratio, age ratio, clutch size, infertility, brood size, significance of first nesting effort, potential life span, competition between and replacement of one grouse by another, and hybridization. An instance of "introgressive hybridization" between genera is documented in this chapter, although it is not named as such. The hunting season, with its many effects, is considered in Chapter 6. Regulations and effects of hunting on the grouse are the main subjects considered.

Sixty-six references are listed under "Literature Cited." A list of scientific and common names of plants mentioned in the text is appended. The book is indexed.

Some minor criticisms seem to be in order. It is difficult to justify unidentified illustrative material in a technical bulletin. Granted that pictures add interest to a book, it seems to the reviewer that if an illustration warrants space it should make a point and be captioned. The publication is one of a series of Technical Bulletins by the Michigan Department, but it is not numbered. The consistent use of the word "data" in the singular is disconcerting to the reviewer. Figure 45 is of doubtful value and might well have been omitted. On page 17 there is an instance of second-hand reference that seems to be in error. The original source of this quotation appears to have been *Forest and Stream* for October 9, 1879, page 705 (*see* Robert Ridgway, *Birds of Illinois*, Part I, page 14) not *Field and Stream*.

Despite these critical comments the reviewer's over-all evaluation is that the report is valuable, timely, and well done.—MAURICE F. BAKER, Alabama Cooperative Wildlife Research Unit, Auburn, Alabama.

Ecological Life History of the Warmouth (*Centrarchidae*). By R. Weldon Larimore. Illinois Natural History Survey Bulletin, Vol. 27. Art. 1. 1957. 83pp.

The Fisheries Publication Award of The Wildlife Society for 1957 was given to R. Weldon Larimore for this life history of a relatively common but little known fish. The methods used in collecting and analyzing the data were mostly standard, but few "life histories" have included as many aspects of life as are reported in this bulletin. Larimore discusses habitat requirements, food habits, annual sexual cycle, fecundity, courtship and spawning behavior, embryological and larval development, age and growth, length–weight relationships, parasitism, group and feeding behavior, and the role of warmouths as food fish, sport fish, laboratory animals, and as members of artificially established populations in ponds and reservoirs. Although the amount of information on some of these topics is rather meager, the author appears to have gleaned much of the information available from his own field and laboratory observations and experiments, from other members of the Illinois Natural History Survey, and from the scattered publications on the warmouth.

Without diminishing the credit to the author, mention should be made of the fact that the quality of the publication and the research is at least partly the result of the rather unique organization for which he works. Identification of food organisms was verified by specialists, most of whom are on the staff of the Illinois Natural History Survey and are housed in the same building with the author. Many field observations were possible through the assistance of other staff members. The bulletin shows the effects of careful meticulous editing and includes more illustrative material than would be possible in most other publications. The text is not wordy but neither has it been so excisingly edited that details of observation and methodology have been eliminated under the guise of brevity.

There is little statistical treatment of the data, and there are few places where such treatment would clarify or add to the results. It would have been helpful to include data on the sample counts of eggs so that the reader would have a measure of the variances in the estimates. The most serious error, in the opinion of the reviewer, was the calculation of annual length increments from the average calculated lengths of all age classes combined. While this is a common method of computing increments, several authors have recognized the errors inherent in the method. Only those fish that complete the year of life should be used in computing increments for a given year. The average calculated length of all fish (including many that do not reach the sixth year) at the end of the fifth year should not be subtracted from the average calculated length of all fish at the end of the sixth year to determine the increment during the sixth year. The effects of computing increments in this way cannot be evaluated from the data given in Larimore's paper, since the data for the 1948 and 1949 collections have been combined, but a negative increment for the eighth year of the 1941 year class is an example.

Growth in a new reservoir, Venard Lake, was shown to be about the same as in an established population in Park Pond, but the Venard Lake warmouth had fewer parasites and (p.66) ". . . a consistently higher coefficient of condition (C) than

had warmouths of similar sizes taken from Park Pond." No data were presented to support the quoted statement. Elimination of these data and combining the 1948 and 1949 growth data seem poorly advised when other observations are given in detail.

While the reviewer has pointed out what he considers to be weaknesses of the bulletin, he believes that this ecological life history may well serve as a model for much-needed similar studies on other species of fish.—K. D. CARLANDER, Iowa State College, Ames, Iowa.

Conservation of Natural Resources. Edited by Guy-Harold Smith. John Wiley & Sons, Inc., New York, N.Y. 1958. Second edition. xi+474pp., illus.

The first edition of this general college text on conservation was published in 1950 as a revision of an earlier work by Parkins and Whitaker. This reviewer covered the 1950 edition for *The Journal of Wildlife Management* (1951. 15[1]:118–119). Comments below are largely devoted to comparing the new edition with the first.

Organization of the book remains essentially the same: 23 chapters but with one added on "Economics and Conservation" and one dropped, "Tree Crops." The chapter formerly called "The Agricultural Prospect" is retitled "The Land We Possess." Editor Smith authors five chapters, one more than before. Eighteen other authors, five of them new, contribute to the volume.

Most of the chapters, including Dambach's on wildlife, are only slightly changed, mainly by updating the statistics. The six chapters by new authors are completely rewritten.

"Economics and Conservation" is by Harold H. McCarty, of The State University of Iowa. He notes that ". . . the science of economics serves first to help people define conservation problems in ways that will provide a basis for the formulation of intelligent public policies; and secondly to determine the relative costs of alternative methods of carrying out these policies." The problems of resource economics are covered in very general terms. Both "fund" and "flow" resources (= nonrenewable and renewable) are primarily tied to our price system. Where this proves to be inadequate to protect the public or the future interest, subsidies of various sorts are used to encourage conservation. Government control is rarely used. The author recognizes that this often results in conflicts of interest, ". . . that to conserve one thing may mean to destroy something else. . . ." Here, as elsewhere in the chapter, examples that would clarify the points are lacking.

The chapter on irrigation by H. Bowman Hawkes, University of Utah, is primarily a résumé of the extent and growth of irrigation, the public policies concerning it, and the laws concerning water rights. "Reclamation of Wet and Overflow Lands" is by Lowry B. Karnes of Bowling Green State University. It is devoted mostly to the types and extent of drainage enterprises. It recognizes the controversial nature of drainage but barely mentions wildlife in connection with it—and waterfowl not at all. The U.S. Fish and Wildlife Service is referred to as the "Biological Survey." The chapter on mineral resources, rewritten by Editor Smith, gives more attention to stockpiling than formerly and covers recent national policies. The other two rewritten chapters are "Conservation of Man" by Lawrence A. Hoffman, Ohio State University, and "State and Local Planning" by Harold V. Miller, Tennessee State Planning Commission.

This text generally serves its purpose quite well —a comprehensive, touch-the-high-spots coverage of the vast field of natural resources. Possibly one should not expect more within a single volume of less than five hundred pages. However, to the professional conservationist, there seem to be a number of obvious and serious gaps. Three will illustrate: The great modern problems of "rurbanization" of much of our best lands is given but a slight mention, as it was in the earlier edition; in the treatment of flood control, no mention is made of the Watershed Protection Act of 1954, a major factor in this field; the tremendously important fresh-water sports fisheries still are not recognized in the "Fisheries for the Future" chapter.—FRANK EDMINSTER, Soil Conservation Service, U.S. Department of Agriculture, Richmond, Virginia.

The Federal Lands: Their Use and Management. By Marion Clawson and Burnell Held. The Johns Hopkins Press, Baltimore. 1957. xxi+501pp., illus. Cloth, $8.50.

This book is a comprehensive summary of the economics of federally owned lands of the United States. These lands constitute approximately one-fifth of our total land area and include national parks, national forests, grazing districts, wildlife refuges, and submerged areas of the outer continental shelf. Economics, revenues, and land uses are emphasized. The book is strongly flavored with history and civics as background explanation of the acquisition, development, use, and disposal of federal lands.

The book is written from the basic assumption that federal ownership of land will continue and that federal lands will be managed more intensively in the future. Text material is grouped into six chapters dealing with: (1) origin, development, and area of federal lands, and administering agencies; (2) use patterns on different types of federal lands, conflicts in use, and potential uses; (3) policy formation and decision making at various levels as influenced by the public, organized groups, state and local governments, and the national government; (4) pricing processes and investments on federal land; (5) revenues and expenditures; and (6) a look into the future, including an exploration

of management through a federal land corporation in the United States.

An appendix of 11 pages is devoted to laws and regulations affecting federal land management. A statistical appendix consisting of 59 tables provides generalized data on subjects ranging from acreages, animal-unit-months, and recreational visits to timber receipts, oil wells, and payments to states and counties. Footnotes in the text tie the discussion to data in the appendix.

The writing style borders on the ponderous. It makes slow reading even for one who "skims." Thoughtful consideration is necessary to full understanding. At the same time, the book leaves the reader with a serious appreciation of the value and place of public lands in his life.

The book reveals much of the inner workings, cross currents, processes, and strategy in government in its management of public lands. The authors point out the decreasing concern being given to public lands by the President, Congress, and the public as the complexity of modern life increases. They discuss what they believe to be defects in management, organization, and in the federal budgeting process. They make no outstanding criticisms but they do suggest ways to improve the handling of federal lands. They foresee no future major changes in net acreages in federal ownership. They do predict an era of intensive management, accompanied by growth in use and growth in revenues from the federal lands.

If the reader expects to find information about the rocks and rills, the woods and hills, the physical and biological resources of the public lands, he will be disappointed. He will not find the national parks listed, nor the national forests, nor the grazing districts. He will find little about the nature of the resources themselves. This is an economist's book.

Careful reading of this book by the average citizen will broaden his viewpoint about the lands that all of us own. Probably it will make him more sympathetic toward government bureaus and the people who manage public lands. Certainly it will contribute to a better understanding of "behind the scenes" forces that make these lands "click."—DAVID F. COSTELLO, Pacific Northwest Forest and Range Experiment Station, U.S. Forest Service, Post Office Box 4059, Portland 8, Oregon.

Marine Ecology. By Hilary B. Moore. John Wiley and Sons, New York. 1958. xi+492pp. $9.50.

At last there appears a textbook devoted exclusively to marine ecology. The book of that title, written by Hilary B. Moore, brings together much of the pertinent material heretofore residing in specialized references or natural-history texts and presents it clearly and for the most part simply.

Aside from the inevitable typographical errors (e.g., antecology for autecology), only one defect, which will loom large or small depending upon the training and interests of the reader, can be cited—the rather consistent use of the abbreviated form of species names when there is no clear antecedent.

The introductory chapter includes a discussion of the major references relating to the biological and physical characteristics of the sea, with an evaluation of their value within their special areas. Of special interest to many present-day taxonomists, who deplore the seeming lack of regard for proper species determinations by modern ecologists (and others), Dr. Moore makes a plea for careful taxonomic determinations of animals under consideration in ecological studies.

Following the introductory chapter are three chapters outlining the major physical, chemical, and biological environmental factors, with numerous examples illustrating their effect on organisms living in the sea. Of particular interest is Dr. Moore's explanation of complex physical factors, such as tides and currents; this is quite clear and devoid of the usual overtechnical language associated with those phenomena.

The two chapters on habitats cite the major features of each of the usual marine habitats, and in addition give an unusually good discussion of the oft-neglected abyssal and pelagic zones.

One of the strongest points of the book, to the reviewer's way of thinking, lies in the five chapters on organisms of the sea. These are treated in a manner quite reminiscent of the good natural-history books (e.g., Flattely and Walton's *The Biology of the Sea Shore* and MacGinitie and MacGinitie's *Natural History of Marine Animals*). Plants are given equal weight in the discussion with animals where their role demands it. The organisms are discussed not only in relation to their interaction with the physical environment but in relation to their interaction with each other.

Perhaps the most unique and refreshing section of the book is the final chapter, which is titled "Review" and which sets *Marine Ecology* apart from the usual ecology textbook. In this chapter, Dr. Moore makes broad statements concerning the sea as an ecological unit, which perhaps run the risk of being overly generalized, but the risk is worth the benefit to the reader.

In summary, *Marine Ecology* is a well-written, nicely illustrated textbook which adequately covers the subject matter in a manner likely to stimulate the reader to attempt further investigation into the field.—J. A. RIEGEL, Department of Zoology, The State College of Washington, Pullman, Washington.

The Bobcat of North America. By Stanley P. Young. The Stackpole Company, Harrisburg, Pennsylvania, and The Wildlife Management Institute, Washington, D.C. 1958. xiv+193pp. $7.50.

The Bobcat of North America is the fourth and final contribution by Stanley Young in his series of monographs on the large predatory mammals. It was preceded by *The Wolves of North America* in

1944; *The Puma, Mysterious American Cat* in 1946; and *The Clever Coyote* in 1951.

There are eight chapters, twenty-nine plates, ten figures drawn with pen or charcoal, two graphs, and ten tables. Every chapter has a black and white headpiece by Harold Cramer Smith of the Oregon Game Commission, and the frontispiece is a full-color reproduction of a painting by him. Each drawing shows a bobcat in a pose or situation related to the chapter heading. The one for Chapter 3, "Habits and Characteristics," depicts a country-store argument over the weight of a bobcat. The plates are of varying size and quality. They include photographs from a number of sources and sketches by Mrs. Bess MacMaugh of the Bureau of Sport Fisheries and Wildlife and others. The extensive list of references includes 800 titles.

Entire pages of the text frequently consist of quotations. Information is presented from a variety of sources, from the chance observer to the highly trained biologist. Much use is made of data provided by a half century of work done by the Biological Survey and the Fish and Wildlife Service. Sometimes the author did not comment on the quoted material and in a few instances the reviewer wondered what the author's views might be. Usually, however, definite conclusions are presented in the book.

The author's thorough review of the literature and interest in bobcat lore are very apparent. The origin of the term "wild-catting," as applied to unsound undertakings, and the discovery of catnip as a lure and many other miscellaneous points are discussed. One gets a chuckle out of statements that burying traps in a manure pile often removes all other odors, that the scent preparation ". . . may be used within three days after mixing, but it is more penetrating when it is about a month old . . ." and that it takes "intestinal fortitude" to remove a live bobcat from a trap.

The Bobcat of North America should have a wide reader appeal. Moreover, it will be useful to both the layman and the trained biologist. In fact, the author's lively and pithy style in covering the biology and lore of the bobcat will appeal to anyone who has an interest in bobcats. Specific data are given on their life history. The races of the bobcats are treated at the beginning under Chapter 2, "Distribution," and again in Chapter 7, "Races of the Bobcat." A good discussion of the different control philosophies and measures is given in Chapter 6. In the Conclusion the author summarizes his views on the place of the large predators, and says, "May these animals never cease to have a place in our North American fauna. . . ."—LLOYD W. SWIFT, U.S. Forest Service, Washington, D.C.

EDITORIAL ACKNOWLEDGMENTS

In closing my last issue, I am deeply conscious of the many persons whose co-operative efforts contribute to each volume of THE JOURNAL OF WILDLIFE MANAGEMENT. During the last 3 years, I have found our authors to be extremely patient and helpful; members of our Editorial Board have been consistently conscientious in processing over 400 manuscripts and in supplying the editor promptly with objective and carefully thought-out critiques. Most of the manuscripts submitted to THE JOURNAL go out to referees, whose critical contributions, although rendered anonymously, have been extremely important. THE JOURNAL thus represents a large-scale effort in which a great many members of The Wildlife Society participate.

It is indeed a pleasure to acknowledge the editorial help of so many associates, and, in particular, the invaluable assistance of our Executive Secretary, Dr. J. P. Linduska, and his predecessor, Dr. D. L. Leedy, whose management of THE JOURNAL's business affairs constitutes such a quiet task of tremendous proportions.—J. J. HICKEY.